NEXT GENERATION INTERNET

Open Call 5

The TikTok Observatory: Interconnecting Junkipedia and Tracking Exposed's monitoring infrastructures

Deliverable 3: Experiment Results and Final Report

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Deliverable 3: Part I

Analysis, results, and wider impact

1 Abstract <Approx 100 words>

When analysing social media platforms, their proprietary recommendation solutions are considered to be “black boxes”. The complexity and opacity of those algorithms is in turn translated into methodological opacity: often a single recommending system is considered, without factoring in potential differences across sections of the same app or differences between web and mobile interfaces. To address this we conducted an investigation comparing the suggested content on the TikTok Web interface and its Mobile application across a variety of sections.

Our contribution is both empirical and technical. For the former, a report will consider differences and similarities among interfaces - web or mobile - for what concerns user recommendations across sections, driving and informing further research.
This required the development of an ad-hoc cross-application infrastructure, our technical contribution. It combines Junkipedia’s Mobile analysis solution, as developed by the Algorithmic Transparency Institute, and TkTrex, a web-browser-based software developed by Tracking Exposed. Additionally, we will provide our research protocol and methodology to contribute to further research on the platform.

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2 Project Vision

Our overall goal is to inform the creation of an open-source and accessible infrastructure to monitor algorithmic trends on TikTok, and possible algorithmic demotion/promotion related to censorship. We aim to empower researchers through three main contributions:

a) A detailed technical report considering the differences and similarities of TikTok's algorithmic systems between mobile and web;
b) An open source and accessible infrastructure for the study of the platform, informed by the result of the technical report;
c) A research protocol and methodology, informed by our findings and leveraging on the provided infrastructure.

More specifically, this experiment will try to answer whether the browser application can be used as a proxy to investigate the platform as a whole, focusing on the different points of contact with the users, such as the For You Page, search results, and audio recommendations.

This is particularly relevant due to the difficulties of accessing TikTok's data, as the platform does not provide any form of official access to it - such as through a public application programming interface (API). Given the lower technical barrier to accessing data from the platform through web-based infrastructures and protocols, we aim to empirically test its validity and empower researchers based on these results.

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3 Details on participants (both EU and US)

Marc Faddoul – Project leader, coordinating the overall scope and outcomes, coordinating the two teams working on the projects.

Marc Faddoul is a transdisciplinary technologist, expert on recommender systems and algorithmic audit. He carried out research on algorithmic systems in academia (UC Berkeley), big tech (Facebook AI) and start-up environments (Bloom, Jalgos). He went from building algorithms to analysing their impact on society, and now strives to defend the interests and digital rights of civil society. He is part of experts committees for the French Digital Council (CNNum) and media regulator (ARCOM), and is regularly called upon to comment on AI and society by WSJ, The Guardian, Le Monde and more.

Salvatore Romano – Research leader, coordinating the experiments and the report writing

Salvatore Romano is a Social Psychologist working on Algorithmic Accountability. He is the Head of Research at Tracking Exposed, where he combines qualitative and quantitative analysis to assess the impact of social media's algorithms on society. He works at the intersection of media campaigns, academic publications, and technical reporting for legal proceedings.

Gaetano Priori – Mobile application analyst, will be dedicated to the data collection on mobile.

Gaetano Priori is a Mobile Security expert with more than 5 year of experience in penetration testing and cybersecurity. With Tracking Exposed he has extended the organization capabilities to the world of mobile application analysis with a a research that was focused on the privacy implications of the apps that orchestrate the workers of the gig economy.

Ilir Rama – Researcher, will be dedicated to the data collection on web and the methodological part of the report**.**

Ilir Rama is a researcher interested in digital platforms, social media, and algorithms. He holds a PhD in Sociology and Methodology of Social Research from the University of Milan, where he is a post-doctoral researcher studying social media and cultural production. As part of Tracking Exposed's research team, he analyses platform's algorithms using a combination of quantitative and qualitative methods.

Giulia Giorgi – Researcher, will be dedicated to the elaboration of the results and the conclusion of the report.

Giulia Giorgi is post-doctoral researcher at the University of Milan, where she holds a PhD in Digital Sociology. For Tracking Exposed, she is part of the research team, designing and conducting original investigations across different platforms. Her interests include TikTok, digital cultures, and visual methodologies.

Justin Yeung – Researcher, working on data collection and data analysis.

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Justin Yeung is a communication science and digital humanities student at the University of Amsterdam and Leiden University. His research interest lies within communication in the phygital world, tech regulations and philosophy and computational methods. Justin is as well working for multiple research projects on mass surveillance at the Institute of Political Science, Leiden University and deliberative quality on social media at the Amsterdam School of Communication Research (ASCoR).

Cameron Hickey – Director at ATI, dedicated on the data collection platform for mobile

Cameron Hickey is the director of the Algorithmic Transparency Institute. Hickey was formerly a research fellow at the Shorenstein Center for Media, Politics and Public Policy at Harvard's Kennedy School. As a fellow, he investigated the spread of mis- and dis-information on social media through the development of tools to identify and analyze problematic content. Hickey helped lead the Shorenstein Center's Information Disorder Lab which monitored disinformation during the 2018 U.S. midterm elections. Previously, Hickey covered science and technology for the PBS NewsHour and NOVA with correspondent Miles O'Brien. Hickey has won a News and Documentary Emmy Award and a Newhouse Mirror Award for his journalism and was also a Knight Foundation Prototype Grantee for his junk news monitoring tool NewsTracker, and won a 2019 Brown Institute Magic Grant to investigate inauthentic activity on social media. His work has appeared on the PBS NewsHour, NOVA, Bill Moyers, American Experience, WNET, and The New York Times.

Athanasios Andreou – Researcher, will be dedicated on data collection and analysis on mobile.

Athanasios Andreou is a computer science researcher, broadly interested in security & privacy, and bringing transparency in automated decision making processes. He received his PhD from Sorbonne University, France in 2019, and is currently working with the Algorithmic Transparency Institute, USA, focusing on bringing more transparency on how online platforms work, particularly on how they use their users' data, and the type of content they disseminate. His research has received several distinctions so far, such as being nominated as the runner-up for the 2019 CNIL-Inria Award for Privacy Protection, the runner-up for the 2019 Caspar Bowden PET Award for Outstanding Research in Privacy Enhancing Technologies, and the winner of the 2020 CNIL-Inria Award for Privacy Protection.

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4 Results

Our inquiry into TikTok's infrastructural and algorithmic differences on mobile and web centred around five main areas: For You Page, search, hashtags, sounds, stickers, each of which has resulted in modest yet important differences.

Our most extensive analysis focused on the primary way in which users interact with TikTok: the For You Page (FYP). We created two identical research browsers with a new TikTok account, changing only the device from which we connected to the social media: one profile logged through a mobile device running the app, and one from a PC, using TikTok's browser version.

The methodology consisted of collecting the FYP's recommendations for both profiles twice: once in the beginning and once after running them through our personalization protocol that consists of a long watching session of a topic-coherent list of channels (see D2 document). This net us a total of 325 videos, around 160 per research browser - 80 before and 80 following personalization.

We personalized the profiles by making them automatically watch around 100 videos featuring cats (see TRL section). We considered a profile as properly manipulated if, following our personalization, it was served more videos featuring pets than before. This was indeed the case for both the browser and the mobile version, albeit to a different degree. The browser had a minor difference, going from a single video (around 1%) featuring animals before the protocol to slightly less than 10%. On mobile, however, TikTok served around 4% (3 videos) of animal videos to the profile before our protocol and more than 31% (25 videos) following it.

Examining search results for the queries "Giorgia Meloni", "caro bollette", and "elezioni" showed little differences between web and mobile. The first 100 videos were nearly identical between the two apps. For example, in the videos returned for the query "caro bollette", only nine out of the first 100 showed up on web application and did not appear on mobile. This was the most significant discrepancy, with "elezioni" and "giorgia meloni" differing in only a few videos. Their ranking, however, appears personalized, showing a different arrangement for different users.

Compared to search, the hashtag pages on web and mobile have a slightly different arrangement on the interface, returning more varied results. On mobile, one can search for a hashtag using the "#" symbol and then choose from several different pages, including top, users, videos, sounds, live, and hashtags. When navigating to the hashtags page, a user can look at the specific page for the hashtag, such as "#elezioni". The web differs in that accessing a hashtag's page is only possible by clicking on the hashtag from a video—the top menu that appears on mobile is absent. With regards to the listed videos on the hashtag pages for "#GiorgiaMeloni", "#CaroBollette" and "#elezioni" the differences were stark. On the

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#elezioni page, for example, nearly half of the videos that appeared on the web hashtag page did not appear on the mobile hashtag page. “#GiorgiaMeloni”, and “#CaroBollette” were similarly mismatched. Not only did the videos differ substantially, but those that did appear on both pages were also ranked vastly differently. On web, the ranking seems to be ordered based on video engagement, whereas mobile is algorithmically ranked based on personalization.

Videos indexed on the music results page are constant across devices. Of the first 100 videos we collected on mobile, 99 were present in the results collected from the web-based version. Aside from their mere presence, videos appear in a similar position, with minor variations: the 100 videos from the mobile version are all mirrored in the first 110 results of the web version. The only video appearing in our baseline dataset (mobile) and not on the web version is a video that has been removed.

Unlike the other affordances of TikTok, stickers only have a separate landing page on mobile, where likes rank videos. A user can send the sticker page to a user on the web app, who can view the page but is prompted by a banner to open the TikTok app. This relates to the fact that stickers are only available when creating videos on mobile. At the same time, using them when uploading a video on the web application is not possible.

4.1 Discussion and Analysis on Results

The differences between the web and mobile versions of TikTok mainly concern two main dimensions: interfaces and algorithmic recommendations. While the focus of this research leaned mainly on the latter, parts of the algorithmically managed sections are harder to reach on one version or might present different options for personalization. This limits direct access to some features, such as the hashtag page on the web app or the discovery tab on mobile. Aside from regulating usage flows within the different versions, some options directly affect algorithmic personalization. This is the case, for example, of the different sorting options available on the search page for TikTok’s mobile versions, where users can sort for relevance or recency.

For what concerns algorithmic recommendations, mobile pages tend to have a higher degree of personalization, for example, influencing what videos appear on the hashtag pages or the ranking of search results. This points at the mobile platform as being most suitable for algorithmic research due to two main reasons: a wider adoption for what concerns its user base (as the mobile app is how TikTok is mostly accessed); and a higher degree of personalization, allowing for more points of contact with TikTok’s algorithm.

This is reflected in our findings surrounding the For You Page, where personalization happened on both devices, but it seems more radical on the mobile version. Notably, the vast majority of the videos we saw across our two profiles differed, despite the personalization protocol involving the same channels. This, and a small sample size, requires additional and permanent investigation, which is now possible thanks to the infrastructure alignment and the developed methodology.

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5 Present and Foreseen TRL (Technology Readiness Level)

The currently available technology to investigate TikTok's algorithms consists of tools covering different parts of the platform; however, no available tool allows for comparing the mobile and web apps. This barrier of access is technical, given the difficulties of establishing and maintaining a data-capturing infrastructure on mobile compared to web-based TikTok. Additionally, data has to be captured and processed in a way that allows comparison with web-based tools. This requires retooling both web and mobile tools, allowing the reproduction of the same methodology and thus allowing for meaningful comparisons.
The objective is to develop a set of tools to analyze all platform pages with a comparable cross-application methodology.

	Data collection **Web** (Guardoni, Zeeschuimer or Manual)	Data collection **Mobile** (Junkipedia, Manual-nox)	Need to personalize?
FYP	Guardoni / Zeeschuimer	Junkipedia/Guardoni	Yes
search	Guardoni / Zeeschuimer	Manual (NOX)	No
hashtag	Zeeschuimer	Manual (NOX)	No
song	Zeeschuimer	Manual (NOX)	No

Table 1, available tools and software for web and mobile TikTok

We started by considering available tools and software (see table 1). Current web tools, while available and functioning, are limited. For example, they might not provide a browser orchestrator or rely on a specific browser such as Firefox – as is the case for Zeeschuimmer. Conversely, Guardoni and TkTrex did not collect data on all available pages. Moreover, they were primarily developed to scrape content instead of downloading files like the "*SIGI-STATE*" as Zeeshuimmer does, and they were released on Chrome.

All those differences required additional work in developing and adapting existing web-based software to the research needs.

Collecting data from mobile-based infrastructure proved more difficult, as no tool is publicly available as open software. For exploratory tests, we relied on NoxPlayer, a mobile Android emulator. However, the final data collection leveraged Junkipedia's infrastructure to orchestrate recommendations by scraping and collecting the "*SIGI-STATE"* file.

Also, the methodology used to personalize the research browsers needed to be adapted to the data collection systems involved in the experiment and the willingness to compare mobile with

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web applications. For example, it was impossible to use a controlled scrolling of the FYP available on Junkipedia, since the presented videos on this page are not pre-determined. We needed to develop new techniques relying on the channel page instead, which allows controlling more granularly which videos will be watched by the browsers and solve the part of the infrastructure non-overlapping.

Based on such an analysis of the tools and software ecosystem, this project addresses the need for road-map unification among the organizations involved at a technology level in algorithm audit involving TikTok.

The approach to data collection and personalization has shifted since the document's previous versions, resulting in changes to our infrastructure. This has been informed by our preliminary exploratory analysis and by the first iterations of the data collection. For what concerns personalization, we found that accessing videos individually, for example, through a direct URL, did not result in personalization. Thus, we shifted our approach to scroll through the most recent videos of a specific, thematically-driven profile.

Our approach to data collection changed as well. Previous versions collected individual videos based on what was currently being displayed. However, while closer to the natural browsing patterns of users, this created a bottleneck limiting both data collection and comparability, as well as introducing potential biases due to recommendations. To solve this problem, we now directly access the files TikTok saves on both web and mobile versions, from which we extract individual videos and display order. Since no available tool was already capable of this, we needed to develop new features on both infrastructures.

The result is a new combined infrastructure able to perform the same personalization path, collect the same type of data points connected with recommendations, and work simultaneously on the same machine.

The result is a new combined infrastructure able to perform the same personalization path, collect the same type of data points connected with recommendations, and work simultaneously on the same machine.
All the following research around TikTok will be able to repeat the data collection with a cross-application approach, new to the sector, and build on a never achieved complexity and completeness of infrastructure and methodology.

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6 Exploitation, Dissemination and Communication Status

The dissemination of this project will address three main stakeholders: researchers, regulators, and policymakers. Those will be reached in various ways, based on the impact of our findings, as defined by a broader communication strategy.

The research community will be mainly addressed through targeted dissemination and a series of events to empower researchers in the field. Efforts in this sense are directed on two different levels, informing the research community about our findings around TikTok's algorithms, as well as the technical infrastructure that made it possible to address the issue. Researchers will be able to build on our insights theoretically (findings and assumptions) and methodologically (tools and research protocols) as they are free and open source. Dissemination of the findings will take place in a series of conferences and talks; this will allow us to reach researchers across various institutions such as NGOs, universities, and think tanks. In a similar effort, a spotlight on technologies and tools will include similar venues, extended to consider hands-on workshops aimed at sharing technical expertise.

We will participate in the DigiMeth festival hosted by the Centre of Interdisciplinary Methodologies at the Warwick University in UK and the Digital Methods Winter School 2023 at Amsterdam University as two of the most relevant European hub for Media Studies academic researchers. Both will be held between the end of December 2022 and the beginning of January 2023. Additionally, we will participate in the next Mozilla Festival 2023, a pivotal moment in the yearly discussion around research, open software, and digital rights.

The sharing of findings with policymakers and institutional stakeholders will mainly not be carried out in public. Instead, we will send our reports to relevant EU legislators involved in the DSA implementation thanks to Tracking Exopsed's contacts with national authorities like the DPAs and some other groups suggested by the funding organization (NGI Atlantic), such as the Consumer Association.

The legislation typically does not consider device specificities in defining platform rules and requirements. Its algorithms are considered as a single unit. Our findings show that this blind spot can be problematic when substantial discrepancies exist across devices.

Dissemination to the general public is based on the impact and newsworthiness of our findings. Our communication strategy involves significant newspapers and media groups (e.g.: Washington Post, Euronews, Wired), with whom we had occasion to collaborate before. This could help translate our findings to the general public and give us a spotlight to share our research outputs. How findings can be launched by media and resonate with the broader public depend on the magnitude of findings and contingencies, such as media agendas at the time of dissemination. The press campaign will follow the Christmas period when it is more challenging to gain media attention.

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These efforts will be paired with an established communication pipeline defined by our communication strategist. It involves press releases, interviews, and timed releases to appropriate stakeholders and outlets, paired with a solid social media presence bolstered by our network of contacts.

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7 Impacts

This project has allowed Tracking Exposed and Algorithmic Transparency Institute, two leading non-profit civil society organizations in the field of algorithmic accountability, to set up a solid partnership to outlive the grant.

For both organizations, this is the first time they collaborated on a shared repository at such a scale. This is an important precedent, which we should reproduce in the future since it allows the ecosystem to pool resources to develop audit tools that are more robust and with more features rather than replicating efforts. We look forward to continuing this collaboration in the future, and we hope it will inspire the community to pursue such partnerships.

The generated research will be shared to inform relevant stakeholders, such as international academic (and not) researchers, who will use this analysis as a ground base for future investigation on the platform. Since the company shares no public data, and since the research on this tiktok.com still needs a general comprehensive framework, our report will provide a fundamental baseline for further investigations. The work we are conducting is quite technical and quite time demanding, but once it is done, it helps new researchers to focus their study only on the relevant part of the platform and only on the best application.

Impact 1: Since the analyzed platform has a significant impact on the citizens of the EU and the USA, our research is relevant. It will be used to research, investigate, litigate and advocate for change with a cross-Atlantic potential.

A cross-application methodology is crucial to all future investigations on the platform, avoiding blind spots that could encourage algorithmic opacity and non-transparent policies.

Impact3 3.
We developed a protocol harmonizing Guardoni and Junkipedia's infrastructures. Such protocol allows both infrastructures to work in parallel, providing a methodology to analyze and compare the algorithmic personalization of TikTok's For You Page across different applications (i.e., mobile-based app and web-based app).

Additionally, this protocol addresses one of the most common problems in studying recommendation systems: the cold-start. Cold-start refers to a limit in an algorithmic recommendation system, where it struggles to provide relevant content due to a lack of information about the user. In the context of research and auditing, this translates into poor data collection due to usage patterns far from that of an average user.

To address these problems, we provide documentation allowing replication of our research protocol, which leverages the Guardoni software, a free and open-source tool now enriched with new data-collection and browser orchestration features that allow for a cross-application comparison.

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Impact4

The unprecedented knowledge share among EU and USA organizations working independently on TikTok's algorithm audit is crucial to developing a new ecosystem of top researchers and non-profit organizations. Among the few actors involved in this type of analysis, there is rarely enough time and resources to establish a common standard or a cross-organization development plan. On the other hand, platforms like TikTok have a global audience and a massive amount of resources to adjust their algorithm to follow their interest. Moreover, since platforms implement only some of the policies equally across the world, cross-national analysis allows research groups to exploit regional regulations and vulnerabilities in a worldwide effort to push for algorithmic accountability.

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8 Conclusion and Future Work

We compared the differences in algorithmic recommendations across the web and mobile versions of TikTok. Modest yet relevant differences have been identified across versions. Some were given by infrastructural differences, such as different ways to access or index hashtags; some were more directly linked to algorithmic recommendations, such as the different sorting of search results or the For You Page. While not paramount, these differences point to a more substantial relevance of the mobile, app-based version, which should be considered as the baseline for future empirical investigations.

However, the mild nature of these differences does not seem to reveal the irrelevance of one of the two TikTok's applications. Both are worthy investigations. Even if we register substantial technical costs involved with developing and maintaining a mobile-based infrastructure compared to a web-based one, the only way to comprehensively study the platform is to analyze both applications.

This research underlines the need for a new field of algorithm accountability: the cross-application approach to the study of algorithmic systems, considering different platforms (i.e.: mobile and web) and different points of contact (e.g.: different algorithms, such as FYP and search results).

In turn, this requires the development of new software and methodological approaches to the study of algorithms. To this end, we contribute to developing tools and research protocols suitable for cross-platform analysis.

Future research should expand on the focus of these findings by adopting various devices and real-case uses. This means incrementing the number of cases tested, for example, by including iOS versions of the app and different countries or devices and deploying experimental research designs involving real users with different browsing patterns. Such an approach would further narrow the scope of these findings, paving the way for implementing a state-of-the-art data collection architecture based on a combination of natural or emulated mobile devices.

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9 References

10 Glossary

5G	Fifth Generation (mobile/cellular networks)
NGI	Next Generation Internet
R&D	Research and Development
SDN	Software Defined Networks
TRUST-IT	TRUST-IT (Project Partner)
VNF	Virtual Network Function
SETU	South East Technological University (Coordinating Partner)

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