



HAL
open science

How a Multi-Factorial Analysis of Polarization Paves the Way for Innovative Recommendation Strategies

Celina Treuillier, Sylvain Castagnos, Armelle Brun

► **To cite this version:**

Celina Treuillier, Sylvain Castagnos, Armelle Brun. How a Multi-Factorial Analysis of Polarization Paves the Way for Innovative Recommendation Strategies. NorwAI Innovate, Oct 2023, Trondheim, Norway. . hal-04410640

HAL Id: hal-04410640

<https://hal.science/hal-04410640v1>

Submitted on 22 Jan 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - ShareAlike 4.0 International License

How a Multi-factorial Analysis of Polarization Paves the Way for Innovative Recommendation Strategies

Céline Treuillier¹, Sylvain Castagnos¹, Armelle Brun¹

¹) Université de Lorraine, CNRS, LORIA, FRANCE
firstname.lastname@loria.fr

Keywords— Polarization, Social Media, Recommender Systems

The advent of social networks has considerably changed the way we get informed [KvS21]. A recent study from the Pew Research Center¹ has shown that one in five adults gets her news through social media. Paradoxically, despite having unlimited access to information, social media users tend to be less well-informed. This is due, at least partially, to a lack of information resulting from the enclosure of users into filter bubbles, reinforcing their polarization [AF22]. This increasing phenomenon of polarization is at the core of many studies which aim at reducing it.

An intuitive solution in the literature consists in increasing the diversity during the recommendation process, with the hope of expanding users' perception of the information field [GOK⁺21]. But surprisingly, the more polarized users are exposed to confronting views on social media, the more their degree of polarization increases [BAB⁺18]. The balance to be found in terms of diversity of opinions, sources, and content is therefore extremely delicate. Recent studies suggest that it would be more appropriate to tailor the level of diversity and recommendation strategies to behavioral classes [BDVH⁺20, Str21, TCDB22], rather than to maximize diversity in the same way for all users [HKD18, LMMd20, HLB⁺22]. To this end, user polarization behaviors need to be understood and finely modeled.

Recent work has made it possible to detect and even quantify polarization [CRF⁺11, MGM18]. Nevertheless, the few existing metrics, although defined in a continuous space, often lead to an unimodal distribution of data once applied to users' interactions, making the distinction between polarized and non-polarized users difficult to draw. Furthermore, each metric relies on a single factor and does not reflect the whole user behavior. Modeling polarization in a single form runs the risk of obscuring inter-individual differences. In the presented work, we propose to have a deeper look at polarized online behaviors.

We collected about 300K retweets from 1K French users between January and July 2022 on Twitter, about the highly controversial COVID-19 vaccine debate. Results show that a multi-factorial analysis leads to the identification of distinct and potentially explainable behavioral classes.

In the process of reducing the polarization phenomenon, such a multi-factorial analysis could be greatly beneficial. In a strongly polarized context, within which users have crystallized their opinions, an input of diverse items does not always have the desired effect as users can be very wary of being exposed to contrary ideas. An accurate characterization of polarization behaviors, as the one we propose, paves the way for innovative and adapted recommendation strategies.

¹<https://www.pewresearch.org/journalism/2020/07/30/americans-who-mainly-get-their-news-on-social-media-are-less-engaged-less-knowledgeable/>

References

- [AF22] Marina Azzimonti and Marcos Fernandes. Social media networks, fake news, and polarization. *European Journal of Political Economy*, page 102256, 2022.
- [BAB⁺18] Christopher A. Bail, Lisa P. Argyle, Taylor W. Brown, John P. Bumpus, Haohan Chen, M. B. Fallin Hunzaker, Jaemin Lee, Marcus Mann, Friedolin Merhout, and Alexander Volfovsky. Exposure to opposing views on social media can increase political polarization. *Proceedings of the National Academy of Sciences*, 115(37):9216–9221, 2018.
- [BDVH⁺20] Abraham Bernstein, Claes De Vreese, Natali Helberger, Wolfgang Schulz, Katharina Zweig, Christian Baden, Michael A Beam, Marc P Hauer, Lucien Heitz, Pascal Jürgens, et al. Diversity in news recommendations. *arXiv preprint arXiv:2005.09495*, 2020.
- [CRF⁺11] Michael Conover, Jacob Ratkiewicz, Matthew Francisco, Bruno Gonçalves, Filippo Menczer, and Alessandro Flammini. Political polarization on twitter. In *Proceedings of the international aaai conference on web and social media*, volume 5, pages 89–96, 2011.
- [GMGM18] Kiran Garimella, Gianmarco De Francisci Morales, Aristides Gionis, and Michael Mathioudakis. Quantifying controversy on social media. *ACM Transactions on Social Computing*, 1(1):1–27, 2018.
- [GOK⁺21] Fausto Giunchiglia, Jahna Otterbacher, Styliani Kleanthous, Khuyagbaatar Batsuren, Veronika Bogin, Tsvi Kuflik, and Avital Shulner Tal. Towards algorithmic transparency: A diversity perspective. *arXiv preprint arXiv:2104.05658*, 2021.
- [HKD18] Natali Helberger, Kari Karppinen, and Lucia D’Acunto. Exposure diversity as a design principle for recommender systems. *Information, Communication & Society*, 21(2):191–207, 2018.
- [HLB⁺22] Lucien Heitz, Juliane A Lischka, Alena Birrer, Bibek Paudel, Suzanne Tolmeijer, Laura Laugwitz, and Abraham Bernstein. Benefits of diverse news recommendations for democracy: A user study. *Digital Journalism*, pages 1–21, 2022.
- [KvS21] Emily Kubin and Christian von Sikorski. The role of (social) media in political polarization: a systematic review. *Annals of the International Communication Association*, 45(3):188–206, 2021.
- [LMMd20] Gabriel Machado Lunardi, Guilherme Medeiros Machado, Vinicius Maran, and José Palazzo M. de Oliveira. A metric for filter bubble measurement in recommender algorithms considering the news domain. *Applied Soft Computing*, 97:106771, 2020.
- [Str21] Jonathan Stray. Designing recommender systems to depolarize. *First Monday*, 27, 2021.
- [TCDB22] Celina Treuillier, Sylvain Castagnos, Evan Dufraisse, and Armelle Brun. Being diverse is not enough: Rethinking diversity evaluation to meet challenges of news recommender systems. In *Fairness in User Modeling, Adaptation and Personalization (FairUMAP 2022)*, 2022.

How a Multi-Factorial Analysis of Polarization Paves the Way for Innovative Recommendation Strategies

Céline Treuillier - Sylvain Castagnos - Armelle Brun
celina.treuillier@loria.fr
Université de Lorraine - CNRS - LORIA (FRANCE)

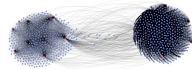
- To limit online polarization, **diversification** appears as an intuitive solution [1]
- Balance** is delicate in terms of diversity of opinions, sources, and content [2] → **Need to adapt the level of diversity and recommendation strategies according to behavioral classes**
- Diversification does not always bring a **positive effect** [3],[4]

- Can a multi-factorial analysis help to better identify classes of polarization behavior?
- How can recommendations be adapted to identified classes of polarization behavior?

Twitter Dataset

Thematic: COVID-19 vaccine debate
Period: from 01/01/22 to 31/07/22

20 elite users (5: pro-vaccine / anti-vaccine)
1,000 standard users (retweets)



Graph of standard users' interactions on elite users' tweets

Polarization Factors

Entropy-based factors to evaluate users' behavior based on all their interactions

$$H_N(Z) = \frac{-\sum_n P(z) \log(P(z))}{\log(n)}$$

Opinions

H'_{Op} Distribution of a user's interactions within confronting communities

Sources

H'_{So} Distribution of a user's interactions on information sources

Results

k-means clustering on three polarization factors:

→ Identification of 4 well differentiated clusters

$$\text{Opinions} \rightarrow H'_{Op} = \frac{\pm H'_{Op} + 1}{2}$$

$$\text{Sources} \begin{cases} H'_{So,pro} \\ H'_{So,anti} \end{cases}$$

Silhouette Index: 0.74
Davies-Bouldin Index: 0.51

Cluster 3
(n=140)

Users interacting with **both** communities, closer to the anti-vaccine community

Cluster 1
(n=365)

Users interacting **only** with the anti-vaccine community

Cluster 4
(n=43)

Users interacting with **both** communities, closer to the pro-vaccine community

Cluster 2
(n=452)

Users interacting **only** with the pro-vaccine community

Intermediate users: 2 interesting clusters made of users that are not completely polarized, but close to anti-vaccine (C3) and pro-vaccine (C4) communities

Innovative Recommendation Strategies

→ Depolarization strategies tailored to identified polarization classes



Adapt the level of diversity according to the degree of polarization of users

Bring diversity for polarized users based on intermediate users' consumption

Other avenues to explore:

- Temporal evolution of polarization
- Context-aware recommender systems

Objective: make sure that diversification has a positive impact on users' consumption, and can help to reduce polarization