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

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The advent of social networks has considerably changed the way we get informed [KvS21]. A recent study from the Pew Research Center<sup>1</sup> 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<sup>+</sup>21]. But surprisingly, the more polarized users are exposed to confronting views on social media, the more their degree of polarization increases [BAB<sup>+</sup>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<sup>+</sup>20, Str21, TCDB22], rather than to maximize diversity in the same way for all users [HKD18, LMMd20, HLB<sup>+</sup>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<sup>+</sup>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.

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

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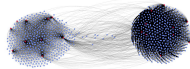
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- To limit online polarization, **diversification** appears as an intuitive solution [1]
- Balance** is delicate in terms of diversity of opinions, sources, and content [2] → **Need to adapt the level of diversity and recommendation strategies according 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

**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**

Opinions →  $H_{Op}^{\pm} = \frac{\pm H'_{Op} + 1}{2}$

Silhouette Index: 0.74  
Davies-Bouldin Index: 0.51

Sources  $\left\{ \begin{array}{l} H'_{so,pro} \\ H'_{so,anti} \end{array} \right.$

**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