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RESEARCH ARTICLE

Posters and protesters

The networked interplay between onsite participation and Facebook activity in the Yellow Vests movement in France

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Abstract
Do social media incite protest movements, how? How does onsite protest shape online communication dynamics on social media? We examine the oft-debated relationship between social media activity and protest, considering the Yellow Vests or Gilets Jaunes movement in France. We use data of temporal and spatial distribution of Facebook activity and onsite events over a year of social mobilization to address these questions within a system of interacting online and offline activity. This study contrasts with others by analyzing mutual influences between online and offline domains while considering collective information diffusion in social networks. The results show that the relationship between social media activity and onsite protests is not constant nor one-sided, but mutual, and that it changes over the course of the collective action in specific and measurable ways. Using online and offline data, we show different mechanisms by which both domains of activity influence each other. Specifically, the creation of Facebook groups impacts the outbreak of protests, and in turn, this outbreak modifies the parameters of information diffusion between users on Facebook. In addition, Facebook content that pertains to the frames of the movement and mobilization affects onsite mobilization efforts. Our work contributes to the modeling of social movements as systems of online and offline events, expanding on studies that traditionally examine the impact of online activity over onsite protest.

Keywords Social network analysis · Complex systems · Human dynamics · Social media · Political participation · Collective action · Protests · Social movements · Facebook · Yellow Vests · France

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Introduction

The relationship between online and offline mobilization is a contested one. For over 2 decades now, scholars have been concerned with understanding whether social media activism can facilitate [59] or—on the contrary—hamper social mobilization [49]. But social mobilizations deploying in the offline and online domains are multifaceted phenomena that are difficult to address in their entirety. The structure of networks of communications between participants may be topologically complex, and may spread over several platforms governed by different rules and dynamics [55]. Their physical distribution may also be scattered and difficult to demarcate [13, 53]. Mobilization may also start abruptly or build over long periods of time, and display several phases. Several authors have tackled this heterogeneity using different data and methods. Different approaches include the examination of time series of online and offline activity to test for plausible directional causalities [8], investigations on how different phases of mobilization impact online activity [26], or how different contents of communications between participants affect events on the ground [23]. Following studies that demonstrate the relationship between internet use and different forms of political participation [4, 10], we track how online activity relates to onsite protests over the course of collective action. We consider the grassroots protest by the Yellow Vests in France (YVs, *Gilets Jaunes* in French) and their Facebook activity as a case study. Using a novel combination of analyses, and longitudinal and cross-sectional data on both online and offline activity, we unearth new interplay dynamics between internet communication and protest activity. Through spatial correlation, we show how online preparation impacted the outburst of onsite protests at national scale. Characterizing the propagation of the movement on Facebook, we show how this outburst modified the dynamics of communications online. Finally, by analyzing the content of different online communications, we show the impact that online activity related to different topics has on intensity of onsite protest, as measured by the number of protesters.

The protests of the YVs emerged from an online petition against the rise of fuel taxes in May 2018, and eventually spread over hundreds of roundabouts by November 2018 and rapidly turned into a sustained social movement which mobilized thousands of people in the streets every Saturday for over a year. Although the movement aimed primarily at taking action in physical spaces, it also considerably invested in social media, particularly on Facebook [12]. Most protesters of the YV movement had no previous experience or political affiliation, were drawn from voters on the far-left and the far-right, and mostly rejected formal alliances with political parties [36]. Despite this lack of formal political platform, continuous weekly manifestations, gathering over 60% of approval of the general population [54], forced the government to backtrack on the decision to increase fuel taxes. As a "movement of crisis" [20], the YVs developed in a context of distress regarding income inequality [29], the internationalization of European economies, and diminished relevance of traditional left-right cleavages [34]. Online, the YVs have been shown to display no clear left- or right-leaning stances, but

clearer attitudes against government institutions, mainstream media, and political élites [17]. As such, the YVs present an interesting opportunity for the quantitative study of online–offline dynamics in emerging grassroots social movements in the West.

Our paper contributes to the research on social media activism, protest, and collective action by disentangling the connection between Facebook communication and onsite events during collective action. We use novel temporal and geographic data of Facebook and onsite activity, distinguishing successive periods of activity between early 2018 and mid 2019, and assessing plausible influences between these periods and activities. In a novel perspective, we rely on the characterizations of information propagation in network cascades online to identify different periods as regimes of online communication dynamics. This allows us to assess the impact of onsite events in the parameters of online communication, and, inversely, the effect of online activity on onsite mobilization. We begin by presenting the case of the YVs and its specific features in Section "Context: the protests of the Yellow Vests", and the state of the art relevant for our study in Section "State of the art: social media and onsite protests". In Section "Data", we present the data collected for this study, and in Section "Results: online-online interplay in the evolution of the socialmovement" we present the main results of this work. Lastly, in Section "Discussion", we discuss the implications of these impacts for the study of the consequences of digital technologies on political participation.

Context: the protests of the Yellow Vests

Named after the high-visibility yellow jackets worn by the activists, the YVs made their first appearance in May 2018 following a petition on *change.org* "to lower fuel prices", and a call on Facebook for a demonstration on November 17, 2019 against the rising fuel prices. The calls to protest on Saturday November 17 were hugely successful: by the beginning of November, the petition had gained 750,000 signatures. A series of weekly grassroots protests (held every Saturday, and called *Actes* by the YVs) started on November 17, 2018 (*Acte I*), rallying hundreds of thousands in France. After three weeks of demonstrations, President Emmanuel Macron suggested holding a series of national discussions (*Grand Débat National*); eventually he backtracked the decision to increase the fuel taxes that had first triggered discontent. Still, weekly demonstrations continued across the country for over a year.

The context of the protest was shaped by cleavages that have long scored the socio-political landscape in France. One of the main sources of persistent economic distress concerned income inequality and redistribution [29]. Yet, another element has been discontent with political elites that predates the movement [33]. By the end of 2018, more than 70% of French citizens did not trust either President Macron or Prime Minister Edouard Philippe [66]. This type of expression of societal unrest related to economic distress and dissatisfaction with political elites was already demonstrated in France and in other countries (notably in Italy, Spain, Greece, and Turkey [19]). However, compared to many previous social movements, the YVs display some unique features. The YVs lacked two main characteristics which are

considered crucial for successful collective action [21, p. 134:160]: on the one hand, they lacked previous experience and/or links with formal political and social organizations; on the other hand, they lack coordination of demands beyond a "minimal" platform, i.e., a master frame [61]. In fact, participants in the demonstrations of the YVs had little to no experience in politics [2, 36], since most of them were first-time protesters with little interest in political affairs [9]. These characteristics motivate approaches based on self-organization explored in our analyses. Furthermore, although the movement gained the support of voters who had previously voted for far-right and far-left parties [54], it rejected any formal alliance, and lacked links, with existing political parties. Instead, the YVs formed their own lists for the 2019 European Parliament elections (with little success). The YVs could not reach a consensus on a common platform; they only had a narrow set of shared demands, which included calls to lower fuel taxes and increase political representativeness. In this context, the various sections of the movement followed very heterogeneous agendas. Some pleaded for the rejection of inequalities, displaying continuity with the traditional demands of the French political left. Others, instead, voiced openly neoliberal stances, supporting free market policies and deregulation, and some demands even veered closely towards radical right-wing topics such as closed borders [36].

Although exhibiting some specific traits, the YVs also share some characteristics with other "movements of crisis" [20]—like the *Indignados* and Occupy Wall Street (OWS)—that have appeared outside France in the last decade, notably in terms of the important role of social media, and in particular Facebook [12]. Besides the initial *change.org* petition (receiving nearly one million signatures before the outbreak of onsite protests), the YouTube video that first called on protesters to wear a yellow safety vest as symbol of discontent garnered 5 million views. Meanwhile, online calls to protest multiplied on Facebook [12] just as the onsite protests were blooming. What remains to be addressed, however, is the interdependence between online activity and onsite protests during the course of collective action.

State of the art: social media and onsite protests

Research on social media activism and protest, or "connective action" [10, 31] provides some answers to the puzzling link between the Facebook activities of the Yellow Vest and onsite protests. The literature questioning the relationship between the online and offline dimension of collective action is rapidly expanding [37, 46, 68], still the debate remains open between two competing camps: while some consider that social media generates novel forms of political participation and organization [4, 38], others contend that digital activism has a limited reach, as aggrieved populations do not have access to (or do not confine their grievances) connected devices [49, 58]. In addition, other scholars highlight the fragility of the "social media effect" over time [1]. Nevertheless, scholars have found that social media activity has acquired growing importance in contentious politics [47, 69]. Evidence from several protest movements, including the Arab Spring [46, 68], Occupy Wall Street (OWS) [7], Black Lives Matter [28], and from far-right mobilization [64] suggests that social media platforms have become part and parcel of contemporary social

movements [22] along with the more classical tools for collective action [71]. What this stream of research is still missing is a more rigorous account of the mutual impact between online communication and offline protests [24, 41] using data from both online and onsite activity. In fact, while growing evidence suggests that social media activity is conducive to protest participation, the study of the interactions between the two has mainly been the object of sample-based quantitative content analyses [27], mass surveys [4] or in-depth ethnographic observations and interviews [25, 30].

Other scholars have been more interested in researching the type of communicative behaviors on social media that pave the way for offline protests, like using hashtags [52], visual content [44], or social media for news consumption [8]. Recently, other scholars have tried to expand existing approaches by measuring the influence of social media communication on physical protests. Some studies show that deviations in social media use are linked to changes in user behavior that are triggered by offline events [42]. Other research on the OWS movement confirmed the association between Facebook activism and offline protests [65]. Another study shows that Facebook communication played a major role in anti-government protests in Guatemala in 2009, even though the protests quickly became self-sustained [37]. Data on online activity has also been used to predict offline dynamics, showing that while this is effective for the case of the OWS movement, it is not for the *Indignados* and the vinegar protests in Brazil [8]. The results from surveys of participants in demonstrations support these findings. In their study of the Egyptian revolution, Tufekci and Wilson [68] demonstrated that interpersonal exchanges through Facebook functioned as a crucial source of information. Further evidence comes from the 2014 Hong Kong Umbrella movement [45], the *Indignados* movement [4], as well as from a study on political participation among the youth in Chile, which also confirm that higher online participation is associated with participation in offline demonstrations [70]. Freelon et al. [26] divided the BLM in periods to determine how onsite events determined online activity. Similarly, Earl et al. [23] examined whether onsite events such as outbreak of protests could explain peak activity online. To the best of our knowledge, only one study has looked at the interplay between online activity and onsite protests in the case of the YVs. Bastos et al. [8] analyze the evolution of the intensity of protests (of the *Indignados*, OWS, and the vinegar demonstrations in Brazil) in comparison with different online communications concerning these protests. Granger causality tests were used on time-series of the intensity of protest and communication signals to determine plausible directions of causality: Do protests anticipate online communications? Does online activity anticipate protests? But this study use data of online activity referring to protests, and not the communication activity of protesters. Special attention must also be granted to the variables with which to measure *intensity* of onsite protest. Throughout this article, we will carefully distinguish between two variables reflecting on the intensity of onsite protest: the number of protesters in a manifestation, and the number of separate manifestations.

Following previous cited studies, we leverage spatial correlations and Granger causality tests to study the interplay between online and offline activity. Crucially, we also consider the structure of online communication networks used by protesters

and the messages they exchange in public Facebook groups. The topology and the configuration of communication networks (i.e., the graph of the Facebook network) and attention parameters determine possible modes of diffusion when observing aggregates of activity. In particular, aggregated activity depending on relayed information over networks (such as creating partisan groups or events for organizing protests), must obey observed—epidemiological—laws with theoretical support and that have been confirmed empirically [18]. In this article, we leverage the parameters of such aggregated activities to identify and characterize modes of communication in different periods of the YV mobilization, and their relationship with events in the offline domain. While these epidemiological approaches have been used in understanding social phenomena [73], these methods have been comparatively less used in the study of social movements and onsite protest. The use of epidemiological information diffusion models to analyze protest has been mostly exploited in explaining dissemination of onsite protest [11, 50].

Our study is guided by three research questions exploring the interplay between online and offline activity. (**Q1**) Does onsite protest correlate with online activity? The state of the art establishes that Facebook is the preferred platform for online communication among the YVs, and where onsite protest was planned [12]. Previous literature also allows to anticipate that the movement propagates on Facebook depending on the underlying structure of the social network, but also on the attention and importance given to the YV movement. As such, we anticipate that onsite protests modify the diffusion of communications online. (**Q2**) Can we leverage information diffusion models in networks to characterize the spread of movement on Facebook? If so, does onsite protest shape the parameters of information diffusion online? Finally, the nature of online communications on Facebook can serve different functions [37]. Scholars have emphasized the consequences of using new communication technologies for collective identity formation in social movements, by informing the claims on behalf of which people mobilize [67], reinforcing group identification as a powerful motivational push to protest [60, 72], or informing how to organize and sustain collective action [16]. Based on these identified mechanisms, we expect that some contents of online communications relate to onsite protest: (**Q3**) Do different contents of online communications relating to claims, identity, or mobilization anticipate onsite protest?

Data

To answer these questions and to further characterize the movement of the YVs in its dual—online and offline—domain of activities, we consider different sources of data. These data cover activities in these two domains, in their spatial (cross-sectional) and temporal (longitudinal) dimensions. In the offline domain, we consider two different data sources for measuring the *intensity* of protests: the number and spatial distribution of manifestations (i.e., road blockades, gatherings) in France at the outbreak of protests on *Acte I*, and the total, nation-wide number of protesters for the successive weekly manifestations (held each Saturday). In the online domain,

we consider public YV Facebook groups, their locations, and the textual communications in the form of *posts*. All collected data and the reproducibility code used to compute the results of this article are available online.[1] In compliance with GDPR regulation, all data were collecte from publicly available sources, and has been further anonymized for this study (see the Acknowledgements section for further details). The data for this study is organized in four dataset (DS1–DS4), summarized in Table 1, and described in detail in this section.

Blockades and gatherings during the *Acte I* (DS1)

DS1 consists of cross-sectional data about the number of roadblocks and gatherings during the first YV protest, *Acte I* (which took place on November 17, 2018). The information was retrieved from the website www.blocage17novembre.fr,[2] which was central in the coordination of *Acte I* [3, 12, 40]. This website was set up by unidentified organizers to help coordinate protests of *Acte I*. In the weeks leading to *Acte I*, the website allowed users to signal protests as geo-located points on a map interface. DS1 includes 785 geo-located gatherings signaled by users across cities, highways, and roundabouts. Using their geo-location, we attribute them to departments of France for spatial statistical analysis.[3]

Facebook groups and events used to organize *Acte I* (DS2)

On the same website (www.blocage17novembre.com), users could also share the URLs of open Facebook groups and events that served to help coordination among protesters. The data includes 134 Facebook groups and 286 Facebook events that were used by the YVs to share information about the time and place of gathering, and other instructions for onsite protests. In this website, users can place groups and events in a map. This allows us to associate them to a geographical location, and to a department in metropolitan France (no groups or events where found to belong to two or more departments). For example, one Facebook event called *Blocage national contre la hausse du carburant Loire St-Étienne* (National blockade against the rise in fuel taxes Loire Saint Etienne), called for a mobilization starting at 7 a.m. on November 17, 2018, with a meeting point in the parking lot of a supermarket. Four thousand nine hundred people declared their willingness participate in this event. The event page also includes instructions for carpooling and other logistical aspects of the organization of protests. While these groups and events in DS2 have the same source as the data on the gathering points from DS1, one crucial difference is that there is a wide variance between the number of Facebook groups and events per department. For example, 350 gatherings are not close to any signaled Facebook

[1] https://gitlab.com/pedroramaciotti/poster-and-protesters.

[2] Later renamed to www.gilets-jaunes.com.

[3] This data produced by the YVs themselves are the only data available, since there is still a lack of official figures. The data also offer a unique account of the geographic distribution of the YVs' protests across regions in France.

Table 1 Overview of the data used in our analyses, organized in four datasets (DS1-4)

Type of data	Dataset	Domain	Content	Source
Cross-sectional (*Acte I*)	DS1	Onsite	Geographic location of 785 blockades and gatherings organized for *Acte I*	Organizers' website www.blocage17novembre.fr
	DS2	Facebook	134 groups and 286 Facebook events used for coordination of onsite protest of *Acte I*	Organizers' website www.blocage17novembre.fr
Longitudinal (*Actes I* to *XXIII*)	DS3	Onsite	Country-wide number of participants per *Acte*	Figures of the Ministry of Internal Affairs
	DS4	Facebook	Nearly 10M posts of the 892 most active YV public groups	Facebook via Crowdtangle's API

coordination element, while some can be associated with several Facebook groups and events. We then consider that the two streams of data can be interpreted as independent proxies of the spatial distribution of online and offline activities, which we analyze in the next section.

Country-wide number of participants in weekly protests or *Actes* (DS3)

To analyze the interplay between online and offline activity over the course of collective action after *Acte I*, we collected longitudinal data on the size (number of participants) of each weekly demonstration. We measured the number of participants using figures from the French Ministry of Internal Affairs reported in the press [12]. Data range from *Acte I* (November 17, 2018) to *Acte XXXIII* (June 29, 2019), which was the last recorded measurement (at 5800 protesters), due to decreasing protest participation. While the choice of this source choice can be criticized for lacking the rigor of classic protest event analysis approaches [39], this is the only available source measuring the YVs' protest size in a systematic and continuous way over time.[4] As Fig. 1 shows, the period includes thirty-three weekly demonstrations that have been attended, on average, by 52,000 participants per demonstration.

Online activity of the most active YV groups on Facebook (DS4)

To account for the evolution of online activity on Facebook, we retrieved data from public groups associated with the YVs.[5] For this, we selected the most active groups in two steps. First, we requested all Facebook groups that had ever used the phrase "Gilets Jaunes" (using Crowdtangle's API) in any of its variants (singular, plural, upper- and lower-case). We identified 21,047 public groups. We then manually

[4] We identified two other sources: figures provided by movement's organizers (*Le Nombre Jaune*), and by the Police Union (*La Police en Colère*). However, none of them covers all the *Actes*. In addition, when data is available in all three sources, they differ in the volume of participants per *Acte*, but not in their increasing/decreasing, and peak trends, which is central for our analyses.

[5] GDPR compliance and data management plan are detailed in the acknowledgments section.

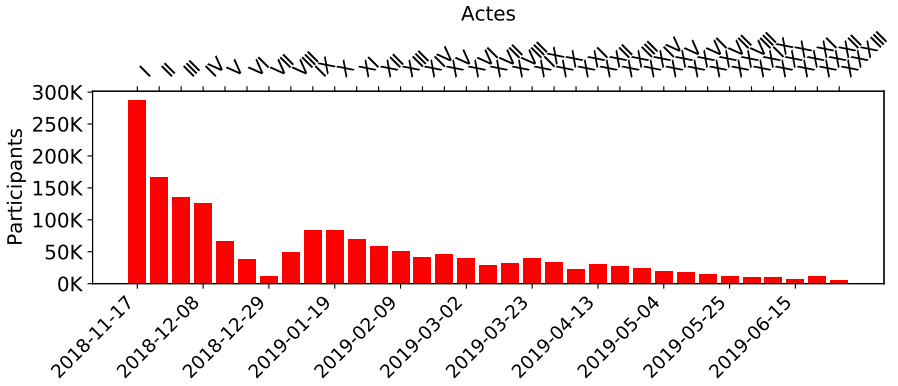

Fig. 1 Number of country-wide protesters per *Acts*. Source: French Ministry of Internal Affairs

examined the 1000 most active groups, and excluded those that just reported on the "Gilets jaunes" without engaging in the movement (e.g., media outlets). We found 892 most active YV public Facebook groups. For each, we extracted all of their posts, from October 1st, 2018 to July 30, 2019 (9.755.214 posts). The date of collection has an impact on the groups retained using this criterion, since groups created later have less time to produce posts and be included in the sample. We addressed this issue by collecting our data at a date long past the selected duration of our study, by October the 7th 2019. This will be important in the next section when studying the dynamics of the creation of Facebook groups. Our data does not allow to account for the activity held in private Facebook groups (see Fig. 2).

As groups are often named after locations (e.g., "*Les Gilets Jaunes de Nimes*"), we were able to associate 532 (60%) of the groups to a department in France. For each post, the data also includes the number of reactions (comments, likes, and shares), but not the date of these reactions. We assume that posts have a short visibility life-time on Facebook [57], and attribute the date of the post also to its reactions. Figure 3 shows the number of posts and post reactions in DS4, suggesting that most groups were created around the *Acte I*; since then the majority of the groups have published posts on a daily basis. In addition, posts and reactions are concentrated in the immediate follow-up of *Acte I*, decreasing afterwards. If there are groups predating November 2018 in DS4 (60 groups by October 15, 2018), it is because they existed before the birth of the YV movement, but then became affiliated with it afterwards and changed their names.

It is crucial to differentiate the groups from dataset DS4 (the most active Facebook groups) from the groups in dataset DS2. The 892 groups from DS4 provide insight into the online exchanges within the movement over a one year period, while the groups and events from DS2 were mostly used to organize *Acte I* at the very onset of the movement. They contain weak volumes of communication, and play a

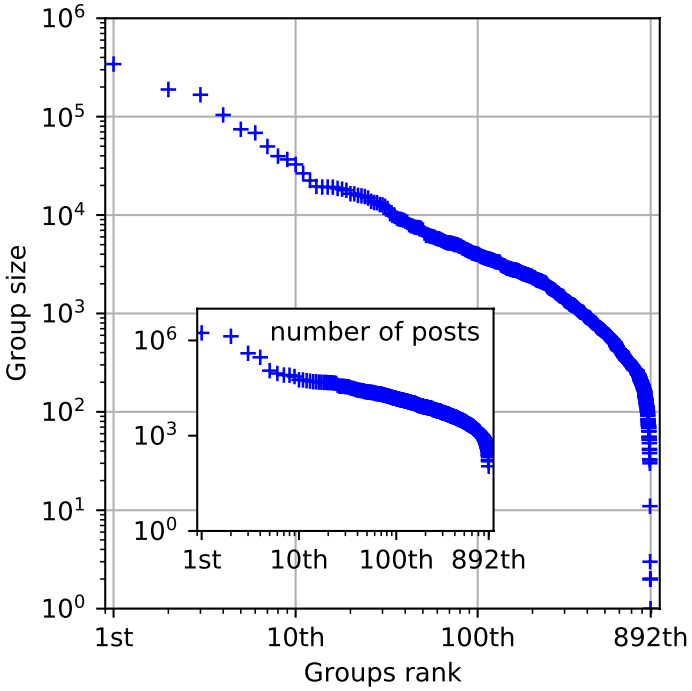

Fig. 2 Group sizes: Size of the Yellow Vest Facebook groups of dataset DS4, measured in number of subscribed members at the time of collection, and ranked by size. The inset shows the groups ranked by number of posts, following a similar distribution

mostly logistical role, in the organization of gatherings. The overlap between groups from DS2 and DS4 is actually very small.

Thematic classification of Facebook posts

The posts from the 892 most active Facebook groups in DS4 include textual content that we use for content analysis of the communication within the movement in addressing research question Q3. From the context of the YV movement outlined in Section "Context: the protests of the Yellow Vests" and the state of the art exposed in Section "State of the art: social media and onsite protests", we identify four relevant types of content or themes addressed in Facebook posts:

(1) **Fuel tax**: The rise in fuel taxes is the initial trigger of mobilization and has been identified as the first demand of the movement [3].
(2) **Mobilization**: Several studies suggest that online activity and offline protests are interrelated, because online communities can generate networks and content serving as co-ordination for mobilization [15].

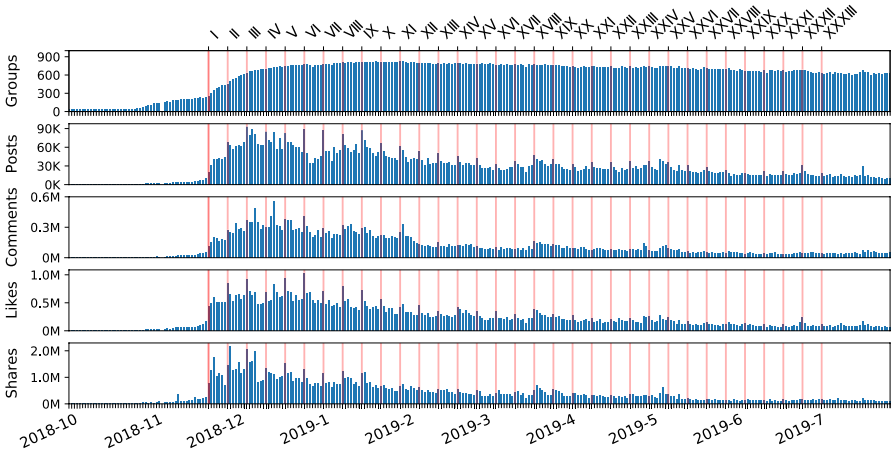

Fig. 3 Facebook activity of the YVs: Daily number of active groups (a group is assumed to be active if it produces at least one post during the day), the number of posts published by them, and post reactions

(3) **Precariousness and life conditions**: Economic factors such income inequality and unemployment rates have been proven to be determinant in the mobilization of the YVs [12].
(4) **Referendum** and **RIC**:[6] One of the main demands of the movement was the installation of a new citizen referendum mechanism [35].

To classify the Facebook posts, we perform a term extraction (of up to 4 g) and measure the term frequency in posts. We then manually inspected the most used terms, to examine all of the terms used in at least 400 posts. This manual inspection allowed to associate examined terms with one of our fours themes. These identified terms related to our four themes are then used as a dictionary for classification for posts. Regular expressions were used to account for different spellings (see the dictionary of regular expressions used for classification in Supplementary Material, Section A.1). Using this classification we can link the posts from DS4 to these four themes, resulting in a multi-classification: posts can be linked to none, and up to four themes.

During manual classification we identified a high frequency of use of variants of the term "Gilet Jaune" in several forms ("gilets-jaunes", "gj", *etc*.). This term is used to refer to the movement itself, in different modes of identity recognition, by lending support (e.g., "Go Gilets Jaunes!"), by referring to protesters (e.g., "the police arrested a Gilet Jaune"), by stepping in as an actor in dialogue (e.g., "the Gilets Jaunes will change France"), or by discussing the future of the movement (e.g., "the Gilets Jaunes have made great progress"). These references to the movement motivate the consideration of a fifth theme.

[6] RIC (*Référendum d'Initiative Citoyenne*) is the demand to consult citizenry by referendum to propose/abrogate laws.

(5) **Yellow Vest movement**: In connection with the state of the art, this fifth theme of posts identify content that contributes to form collective identities [72], and include all mentions to the YV.

In connection with with research question Q3 identified in the state of the art, themes 1, 3 and 4 allow us to address claims and demands, theme 2 allows to address online content about onsite mobilization, and theme 5 provides a simple way of addressing contents involving identity. 842.279 of the 9.755.214 posts (8.6%) of DS4 have at least one associated category (see Supplementary Material, Section A.2, for examples of classified posts). To test the quality of our thematic classification of posts, we asked human annotators to evaluate the quality of the search queries. We selected 15 posts at random for each one of the first four themes[7] and asked 10 volunteers to perform a classification, attributing one or more of our four themes to each post. Human classification achieved similar results than our dictionary-based classification, achieving a 0.84 mean $F1$-score value, with the lowest at 0.729 for theme 3 (Precariousness and life conditions) and the highest at 0.926 for theme 1 (Fuel tax). We measured agreement between human annotators using Krippendorff's alpha, resulting in a value of 0.746 (the details of the performance of the classification are available in Section A.3 of the Supplementary Material).

Results: online–offline interplay in the evolution of the social movement

The phases of mobilization

The data shown in Figs. 1 and 3 depict a complex dynamical system including the online and offline domains. Prior to *Acte I*, 60 of the groups that would come part of the 892 most active YV Facebook groups already existed (see Fig. 3). In the weeks leading the outbreak of *Acte I*, online activity increases, as new groups are created following the first calls to organize on Facebook, and exchanges intensify. Ultimately, *Acte I* is a success, bringing hundreds of thousands of people to the streets, and changing online activity: group creation accelerates, and the volume of the communication flows within the groups sees a sharp increase. Weekly protests ensue, but participation steadily declines during the first 2 months, contrary to what is happening online (see Fig. 1). By *Acte X*, onsite protests increase again, and online activity peaks, both to decline afterwards.

To identify different phases of mobilization we examine the regularity of dynamics of the movement's propagation online at different moments in time. If we observed the cumulative number of groups in time, three distinct regimes of group creation on Facebook can be distinguished (see Fig. 4), as the movement propagates online. Different regimes of propagation can be linked to different underlying online

[7] Theme 5 involves a purely formal criterion, namely, the presence of strings of the form "gj", "Gilets Jaunes", and variants.

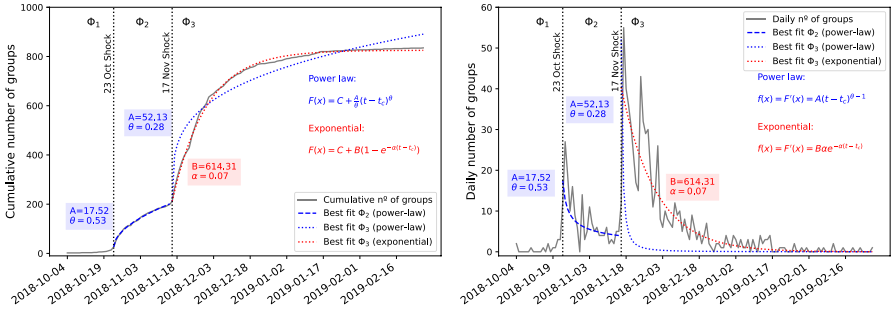

Fig. 4 Diffusion dynamics of the movement on Facebook and response to exogenous shocks, on the accumulated number of groups (left) and the daily number of created groups (right). During $\boldsymbol{\Phi}_2$ group creation follows a power law regime as the movement spreads on Facebook. After the success of *Acte I* the dynamics of group shifts to an exponential regime

activity. We name these three phases as $\boldsymbol{\Phi}_1$, $\boldsymbol{\Phi}_2$ and $\boldsymbol{\Phi}_3$. In networked systems in general, diffusion events are a combination of interactions (knowledge traveling by word of mouth) [51] and external perturbation (knowledge made available to all at once) [18]. Bursts of activity after an external perturbation, and the response of the social system can provide clues by measuring the response function [56]. Many factors can motivate someone to create a YV Facebook group: news seen on television, an email message, a newspaper articles (information broadcasted to several individuals), but also network propagation [63], i.e., seeing a YV group on Facebook and deciding to create a new one, talking about groups over a telephone call, a talk with someone in a protest, in which case epidemiological models help describe the observed aggregated frequencies in time (the rate of group creation). These models include two ingredients [18]: (1) power law distribution of waiting times describing human activity [6], and (2) epidemic branching process describing the cascades of diffusion on the social network. This second process describes how the actions of one individual on the network (and not external influences, such as information broadcasted) can influence another individuals, triggering future actions [62]: how a user can decide to create group after seeing a created group online. The aggregated temporal dynamics dominated by these two ingredients can be described by a power law decay: $A(t) \sim 1/t^{\theta-1}$, with $A(t)$ being the evolution of the aggregated activity (the creation of groups). The expectation is that after initial call to protest launched on Facebook on 23 Oct 2018 (during Phase $\boldsymbol{\Phi}_2$), the creation of groups during follows a power law distribution as users rely exclusively on networked word of mouth to propagate the movement online. In contrast, after the outburst of onsite protest on *Acte I* (during Phase $\boldsymbol{\Phi}_3$), the movement gained nation-wide attention and media coverage, making users aware of the possibility of creating Facebook groups, thus leading to a different type of group creation dynamics. In Fig. 4 we show the cumulative and daily number of created groups, to which we fit power law distributions. The fit is computed in the accumulated number of groups to minimize the effect noises and time-windowing sampling effects, but results are shown on both, cumulative and daily values.

The creation o groups during Phase Φ_2 the fits of a power law ($\theta = 0.53$, std. dev. $= 0.011$) suggesting an underlying network diffusion process. The dynamics of group propagation during Phase Φ_3 are, however, different. Following *Acte I*, the propagation of the movement online might have changed, reflecting a power law distribution with different parameters. However, no power law distribution fits the observed data. The best fit for a power law distribution during Phase Φ_3 is shown in Fig. 4 to illustrate this deviation. As expected, after the attention gained during *Acte I*, the movement not only propagates online by word of mouth effects, and users are made aware the movement and its online dimensions through traditional media. During Phase Φ_3, the aggregated creation of groups follows an exponential distribution, as shown in Fig. 4, with exponential coefficient $\alpha = 0.07$ (std. dev. $= 0.0007$). This change in the nature of network diffusion can be consistent with "fast reaction" regimes [48], in which users react instantly to idea of creating groups. This hypothesis is also connected to the territoriality of groups, as they are name after communes and departments, and are a scarce online resource to be seized by the first to take it. Our data do not allow us to test this hypothesis about the mechanistic causes of the change in diffusion regimes. However, this shift in the dynamics of network propagation provides us with clear support for offline impacting the online domain, as different network diffusion regimes on Phases Φ_1, Φ_2 and Φ_3 are marked recognizable events.

To further organize and guide our analyses in the following sections, we propose the consideration of a fourth phase, Phase Φ_4, distinguishable by online and offline landmarks. On January 19, 2019 (*Acte X*) the daily number of groups producing posts peaks, to decline steadily afterwards, as shown in Fig. 5. This mimics onsite participation. Having diminished since *Acte I*, *Acte X* sees a revival of the movement in terms of weekly number of protesters nation-wide, but only to see a steady decline afterwards (see Fig. 1).

In summary, we propose dividing the evolution of the movement in four phases or periods of time. In contrast with other research interested in the cycles of mobilizations [61], we do not seek to directly establish landmark events to guide the analysis of online activity [26]. We propose a division into phases based on morphological criteria for online activity to then show its correspondence with offline events or limits between periods of well-identified dynamical regimes. The four proposed phases (from Φ_1 to Φ_4, summarized in Fig. 6) will drive the statistical analyses of the next sections, and are defined by the following criteria:

- Φ_1: Before October 23, 2018, at the start of calls on Facebook to protest, with no observed growth of YV groups.
- Φ_2: From October 23 to November 17, 2018 (*Acte I*), at the outbreak of onsite protest. During this period there is observed growth of YV groups in anticipation of first protests.
- Φ_3: From November 17, 2018 (*Acte I*) to January 19, 2019 (*Acte X*), at the point of maximum daily presence of the 892 most active groups.
- Φ_4: After January 19, 2019 (*Acte X*). During this period, there is a sustained decline of online and offline activity.

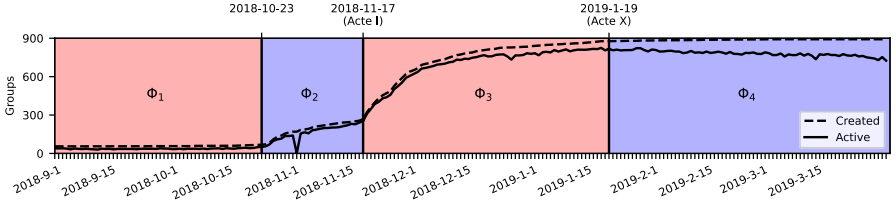

Fig. 5 Cumulative and active number of the identified 892 most active Facebook groups by date. Four phases of the movement correspond to different dynamics of group creation and online activity

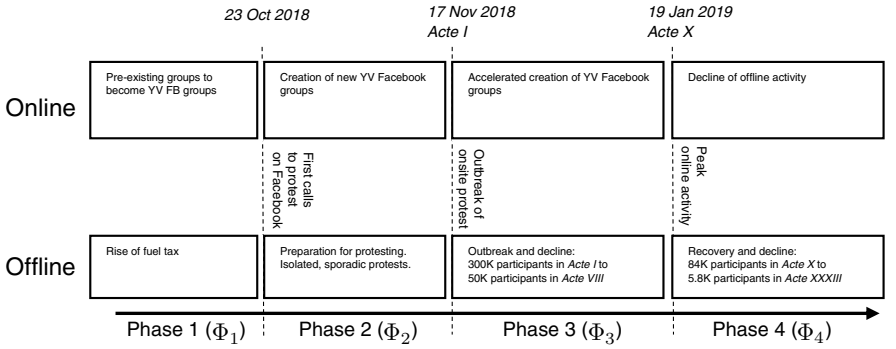

Fig. 6 The four defined phases of the YV mobilization and the principal characteristics in the online and offline domains

Online activity and the outbreak of onsite protest at *Acte I*

In this section, we focus on the online activity preceding the outbreak of onsite protest in *Acte I* and its relation to the spatial distribution of the outbreak. The calls to join demonstrations, launched on Facebook in mid-October 2018, were replicated in several Facebook groups and events. In DS2, we count 134 groups and 286 events on Facebook that were used to set up 785 onsite protests. We examine how the spatial distribution of these groups and events on Facebook relates to the distribution of gatherings. To assess the strength of this spatial relation, we compute the Pearson correlation of the number of Facebook groups and events in DS2 and the number of gatherings in DS1 per department, and per 1.000 inhabitants. We choose to compare densities of protest sites and online groups and events (and not absolute occurrence) in order to separate population effects, where larger presence of groups and protest site might be explained by more people in the measured department. The results, displayed in Fig. 7, show that spatial correlation between groups and events from DS2 and protest locations from DS1 stands at 0.716 (p-value < 0.001). This hints to the effectiveness of Facebook

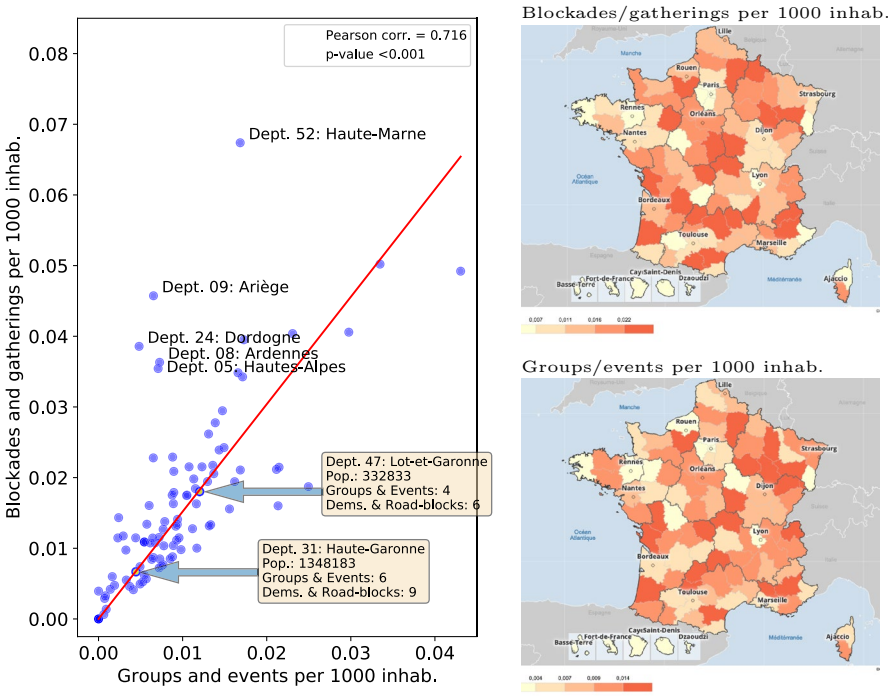

Fig. 7 Correlation between Facebook activity and protest outbreak on *Acte I*—Scatter plot of the number of Facebook groups and events created, and the number of demonstrations, per department, and per number of inhabitants. Outliers are labeled, two departments with low regression residuals are shown in yellow as examples. Spatial distribution of the density of protests and groups and events per department

groups and events specifically intended for organization (from DS2). These were created mostly during Φ_2, and had a plausible impact on the outbreak of onsite protest. Two examples from Fig. 7 help further illustrate these patterns. *Lot-et-Garonne* had 0.012 groups and events per 1000 inhabitants, almost twice of those in *Haute-Garonne*, with 0.005 groups and events per 1000 inhabitants. In *Acte I*, *Lot-et-Garonne* had 0.018 blockades per 1000 inhabitants, almost three times the number of blockades in *Haute-Garonne*, with 0.0065 per 1.000 inhabitants. These groups and events have few to none posts, and include in their description precise and practical information on how, where, and when to conduct mobilizations on *Acte I*.

The consequences of *Acte I*

The success of *Acte I* marked the beginning of weekly demonstrations (see Fig. 1). But this success was also accompanied by new online activity and users' exchanges on the identity and claims of the movement. This is most clearly seen in the

accelerated dynamics of group creation on Facebook, as shown in Fig. 5 when comparing phases Φ_2 and Φ_3. This difference in the dynamics of group creation is consistent with other measurement of Facebook online activity of the YVs [12].

The birth of these new groups is, however, not spatially explained by previous online activity, nor by onsite protests during *Acte I*. The spatial correlation (at the departmental level, and per 1.000 inhabitants) between the number of gatherings of *Acte I*, and highly active groups (from DS4) created during Φ_3 (after *Acte I*) is weak ($\rho = 0.26$, p-value < 0.01). Furthermore, the creation of groups during Φ_3 is also not explained by the the creation of groups previous to *Acte I*, during Φ_2 ($\rho = 0.084$, p-value < 0.5). Simply put, it is not the creation of groups before *Acte I* (Φ_2), or the number onsite protests that explains where new groups were created after *Acte I* (Φ_3). It is probably the visibility of mobilizations in *Acte I* across France that fomented the creation of new Facebook groups, where there were no previous protests or online platforms. Arguably, the creation of these new groups after November 17, 2018, might respond to the hopes of promoting and organizing new demonstrations and thus repeating the success of *Acte I*, or it might be related to the interest in adhering to a now identifiable collective actor: the YV movement. This observation relates to that of Section "The phases of mobilization", providing further evidence for a change in the dynamics of online group creation, and the impact that *Acte I* had on the propagation of the movement online.

The content of Facebook communication

We now turn to our dataset of the 892 most active YV Facebook groups (DS4) to investigate the content of online communications and its relation to onsite protests.[8] For each week, from September 2018 to August 2019, and for each one of the five identified themes from Section "Thematic classification of Facebook posts", we compute: the percentage of active groups (groups that published posts discussing any topic during that week), of posts published, and of reactions (comments, likes and shares) that said posts received. Using these five topic themes (fuel tax, mobilization, precariousness & life conditions, RIC, and the YV movement,), we calculate weekly indicators of the attention given online to these topics. The attention given to the varying online action of each topic is displayed in Fig. 8.

The first question we seek to address is whether the online activity of DS4 during Φ_2 correlates spatially with the outbreak of protests in *Acte I*. To do so, we analyze activity on Φ_2 by topic and by department in France. A cross-sectional analysis of the geographical distribution of this online activity shows weak correlation with the spatial distribution of onsite protests on *Acte I*. The number of gatherings correlates poorly with the number of active groups ($\rho = 0.56$, $p < 0.001$), with the number of posts published ($\rho = 0.54$, $p < 0.001$), and with the reactions given to them during the week before (for all types of reaction $\rho < 0.42$, $p < 0.001$). The spatial correlation between the volume of posts among the 5 different themes and the number of

[8] Facebook groups from www.blocage17novembre.com (DS2) contain a small volume of posts, and little information about the movement's frames, therefore most of them are not included in DS4 and are excluded from the content analysis.

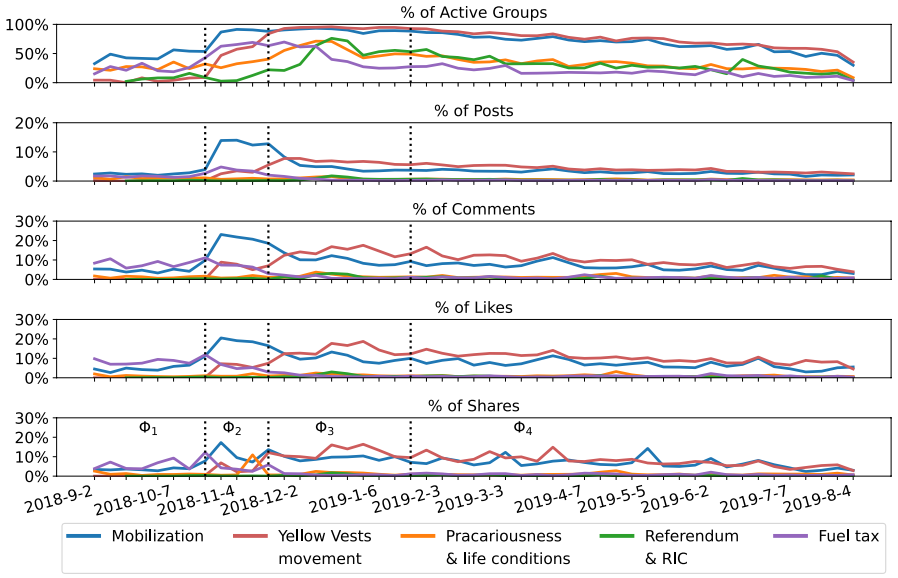

Fig. 8 Issue attention in the Facebook activity of the YVs over time: Online activity related to the main issues on *Acte I* (vertical line) and in the first months

blockades per inhabitant and department is also low (for all topics $\rho < 0.57$, with $p < 0.001$); the correlation with reactions to posts per topic is even lower. Read together with the spatial correlation of groups and events from dataset DS2 used specifically for coordination, these results provide some insight into how the YVs organized themselves online. Groups and events with practical information about gatherings (but with a low volume of posts, and thus low internal debate) does correlate spatially with blockades, while communication on groups with a high volume of exchanges (even about the logistics of mobilization) correlates poorly with blockades. It is remarkable that even discussion about "mobilization" do not have spatial correlation with the geographical distribution protests on *Acte I*.

The results from Fig. 8 suggest, however, that there is a sequence of topics that do receive attention over time. In the month preceding *Acte I* (during $\boldsymbol{\Phi}_1$), groups produce Facebook content related to mobilization, and, to a lesser extent, about a few core demands of the YVs: to lower the "fuel tax" and issues related to "precariousness and life conditions". But during $\boldsymbol{\Phi}_2$, the Facebook groups focus their attention more closely on the issue of mobilization, in anticipation of the protests of *Acte I*. It is also only during $\boldsymbol{\Phi}_2$ that Facebook groups start giving considerable attention to the "YV movement" itself; without, however, eliciting reactions from users. The reactions of users to posts are mainly elicited at first by the issue of the increase in the fuel tax (during $\boldsymbol{\Phi}_1$), and then by "mobilization" (during $\boldsymbol{\Phi}_2$).

While groups did publish posts mentioning the "Yellow Vest movement" during phase $\boldsymbol{\Phi}_2$, it is afterwards, during phase $\boldsymbol{\Phi}_3$ (after *Acte I*), that this topic becomes the main source of expression for users. At the same time, posts that discussed the fuel tax-hike were scarce during phase $\boldsymbol{\Phi}_1$; reactions to these posts, however, were

not scarce. While posts about this issue increased during Φ_2, the reactions to them declined and vanished almost completely by *Acte I*. Despite this decline, groups continued to evoke the issue of fuel taxes well into phases Φ_3 and Φ_4. Figure 8 highlights other important trends with respect to another core claim of the movement: improve democratic representation and establish new referendum mechanisms (RIC). Specifically, Fig. 8 shows that it is mostly after *Acte I* that attention is given to this topic, but ultimately, that only accounts for little attention in Facebook publications.

Aside from encouraging new online activity for organizing and communicating through group creation, the successful demonstrations of *Acte I* seem to have had the effect of concentrating the attention on the movement itself rather than on the issues by which it was formed. The share of attention given to the identity of the movement increases in the months leading to *Acte I*, and remains consistent in time afterwards, becoming a focal point of attention inside the movement.

Long after *Acte I*: a self-sustained movement

By *Acte X*, 96 percent, or 859 of the 892 most active groups, had already been created and were sustaining high volumes of online activity that characterized phase Φ_3 (see Fig. 5). Offline, after having lost steam, weekly gatherings began increasing again. The number of protesters had dropped from around 300,000 to tens of thousands between *Acte I* and *Acte VII*; by *Acte X*, participation had risen again to nearly 100,000 (see Fig. 1). Despite this recovery, *Acte X* also marks a turning point in the number of groups publishing daily posts (see Fig. 5). From *Acte X* onward (on Φ_4), weekly protests continued to take place every Saturday, but attendance declined again, as did online activity. Fig. 9 illustrates this relation by comparing the number of protesters per *Acte* with the number of Facebook groups that were active during that week (from Monday to Friday), and filtered by whether they posted about mobilization or about the YV movement (as defined in Section "Thematic classification of Facebook posts"). While phase Φ_3 sees both a decline of onsite protests and a rise in online activity, phase Φ_4 sees a steady and simultaneous decline of both. Despite seeing a global declining trend, these quantities are also subjected to local, faster variations in time. For example, Fig. 9 shows that in *Acte XXV* there was an unusual increase of attention given to groups concerned with mobilization, all within a global trend of diminishing online activity.

These so-called fast dynamics raise the question about the short-term relationship between online activity and the intensity of onsite protest as measured by the number of protesters at nation-wide scale during weekly protests. To address this question, we use the previously presented content analysis and the Granger causality test to assess whether these variations in the online activity of the movement can explain variations in the volume of participants during phase Φ_4. To separate the global linear diminishing trend of the time-series measuring online and offline activity during Φ_4, from the faster variations around it, we separate each time-series $f(t)$ into two contributions, the fast $f_F(t)$ and the slow $f_S(t)$ contributions to $f(t)$, such that

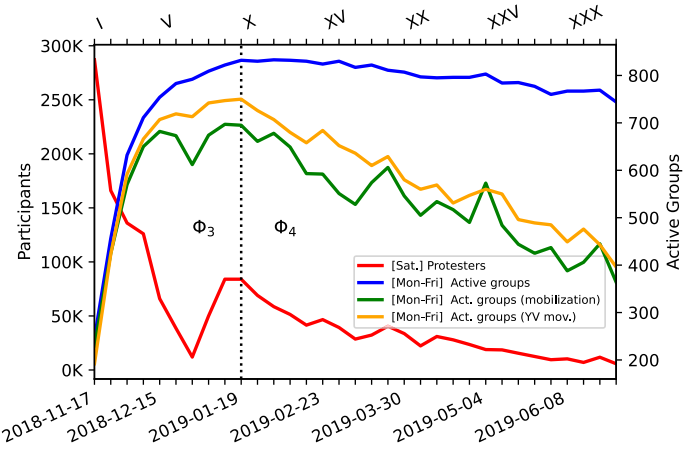

Fig. 9 The decline of the movement online and offline—Country-wide number of protesters every Saturday, and the number of groups active during the days preceding the protests (Monday–Friday), distinguishing those that treated in their posts the topic of mobilization and that of the YVs movement

$$f(t) = f_S(t) + f_F(t).$$

The analysis of the so-called slow time-series $f_S(t)$ for the offline activity and the diversity of online activities (groups active at different times, posts, comments, shares, and likes) offers little conclusion to the plausibility of causal relations, as they all undergo a steady quasi-linear fall during $\boldsymbol{\Phi}_4$ (see Fig. 10). Despite this global shared decay trend, time-series of different activities do display different faster-paced variations of lesser amplitude when compared with the global trend. To investigate whether these variations can plausibly display causal relations we use a Granger causality test on time-series $f_F(t)$. To compute these time-series $f_F(t)$ we propose a simple approach, by considering the slow-paced dynamic $f_S(t)$ to be a linear function of time during $\boldsymbol{\Phi}_4$, and computing fast-paced dynamics as $f_F(t) = f(t) - f_S(t)$. It is easy to see that the Granger causality analysis applied to the original time-series $f(t)$ would render the relation between time-series too dependent on the relative amplitude of slow-paced dynamics. This is why we forgo analysis of the $f(t)$ and concentrate on the new time-series $f_F(t)$ to extract conclusions about the relation between events that might be driving different offline and online activities within the broader context of long-term falling activity.

Before we analyze time-series of fast-paced dynamics $f_F(t)$, we scale them to be able to compare them despite having different units of magnitude (e.g., protesters are in the order of hundreds of thousands, while active groups are in the order of hundreds). To do so, we apply a standard normalization. For each time-series $f_F(t)$ we compute the standard deviation σ,

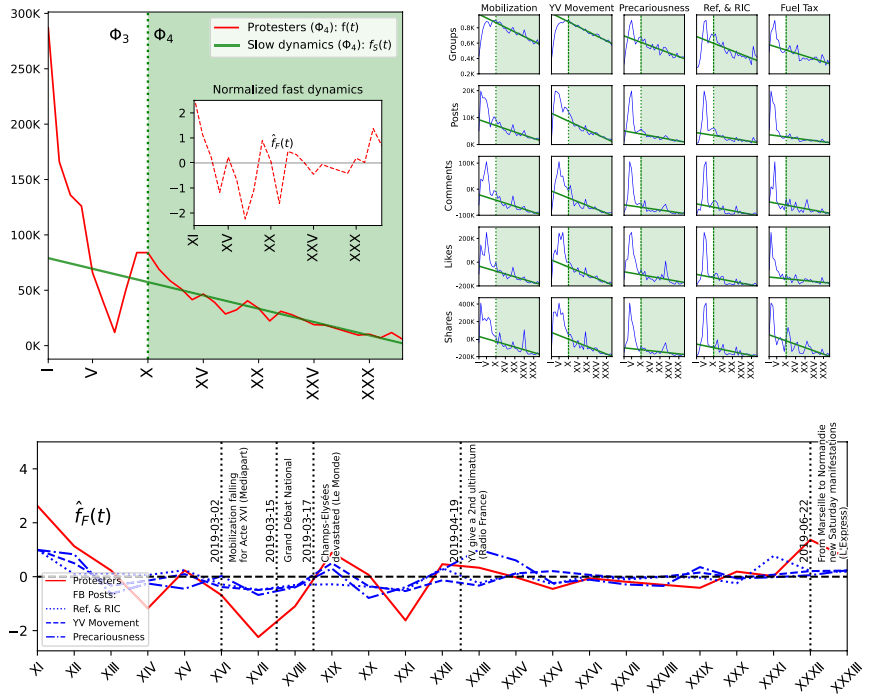

Fig. 10 Decomposition of time-series $f(t)$ of nation-wide number of protesters in fast $f_{\mathrm{F}}(t)$ and slow $f_{\mathrm{S}}(t)$ dynamics, with extracted normalized fast dynamics $\hat{f}_{\mathrm{F}}(t)$ for phase $\boldsymbol{\Phi}_4$ (top left). Fit of slow dynamics for the time-series of different online activities by type and topic (top right). Examples of some unit-less time-series of the number of protesters in offline manifestations, and the number of posts addressing three claims of the social movement on Facebook (bottom)

$$\sigma = \sqrt{\frac{1}{N}\sum_{t=1}^{N} f_{\mathrm{F}}^2(t)},$$

and compute the unit-less time-series $\hat{f}_{\mathrm{F}}(t) = f_{\mathrm{F}}(t)/\sigma$. Figure 10 (top left and right subfigures) shows this process applied to the time-series of the intensity of weekly protests (measured in number of nation-wide protesters), and the fit of the so-called slow dynamics for the time-series of online activities (during the fives days, Monday through Friday, preceding protest that Saturday). Figure 10 (bottom subfigure) illustrates different fast-paced dynamics $f_F(t)$ for different activities, comparing the the unit-less time-series of the number of country-wide protesters, and the number of Facebook posts treating three different issues: Referendums, the Yellow Vest movement itself, and precariousness and life conditions.

Finally, we apply the Granger causality test to the unit-less time-series $\hat{f}_{\mathrm{F}}(t)$ [5, 43], to assess the plausibility of different fast-paced variations of online and offline activity influencing each other. The effect of normalizing the each time-series by

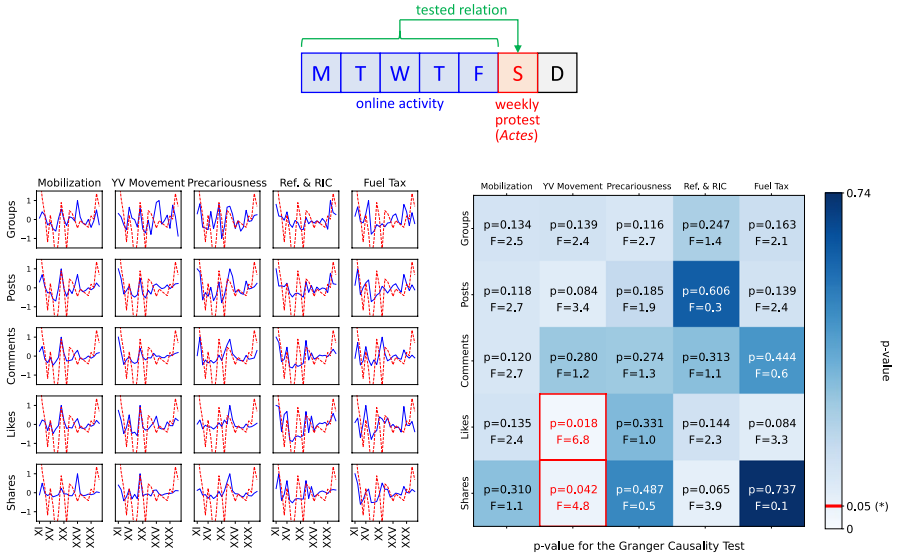

Fig. 11 The online predictors of the number of protesters: p-values of the Granger causality test between the levels of different types of online activity, and the time-series measuring the evolution of the number of protesters for *Acte X*

its standard deviation σ is that the possible noise admitted for each one during the Granger causality test will be proportional to the amplitude of the time-series. The p-values and the F-statistics of the test are reported in Fig. 11 and offer quantitative evidence for the intuition suggested by the dynamics observed in Fig. 9. In line with expectations raised by Fig. 9, the number of active groups discussing content related to mobilization from Monday to Friday has less statistical significance (p-value $= 0.143$) than the number of active groups discussing the YVs movement ($p = 0.109$). However, both quantities lack statistical significance at a threshold of 5 percent. Among the 25 time-series considered in Fig. 11 (5 types of online activity by 5 themes), only a two pass the Granger causality test at 5% significance: the number of likes and shares given to posts about the YV movement itself during the week preceding protests to be held that Saturday. We did not find statistical significance in the treatment of other issues such as the "RIC", "precariousness and life conditions", or in that of the initial grievance on the rise of "fuel tax".

The results of the Granger causality test suggest that the relation between online and offline activity changes at different phases of collective action. This is echoed by observations derived from Fig. 8. During $\boldsymbol{\Phi}_4$, the attention of the users in the movement's Facebook groups is centered around mobilization and the movement itself. But it is the online activity and the discussion around the movement that is most correlated with the volume of protests on the streets. By $\boldsymbol{\Phi}_4$, the movement has established a presence and a rhythm for protesting, making online coordination less relevant. In our time series, offline activity (volume of protests in number of

protesters) is measured on Saturdays, while online activity is measured on the days preceding protests. While our results do not imply causal impact [32], precedence in time provides additional support for the plausibility of online content discussing the movement having an impact in protest turnout.

Discussion

This paper questioned the relation between social media and protests. Following approaches suggesting that online activity offers novel ways to participate in politics [10, 14], we scrutinized the relationship between Facebook activity and onsite protests during the course of collective action, considering the case of the YVs in France. What first emerged is a spontaneous grassroots movement in which face-to-face meetings played a core role in promoting civic engagement [2], the YVs then also relied on social media (and on Facebook in particular) to promote political participation and enhance onsite mobilization [12]. Furthermore, as a "movement of crisis" [20] motivated by distress regarding income inequality [29], with blurred attitudes towards left-right cleavages but clear leaning against government institutions, mainstream media, and élites [17], the YVs present an interesting case to reassess an old question as to the extent of how and why social media incites onsite protests in the current context. In the opposite direction, we also questioned the impact that onsite protest has in the online development of the movement; be it in its diffusion and growth, capacity for organization, and for discussion. In this article we used different quantitative methodologies to address three research questions that guide our analysis into the interplay between online and offline activity of social movements. Figure 12 proposes a summary of our findings, indicating plausible feedback dynamics in the interplay between online and offline activity.

The creation of a different set of Facebook groups and events, that do not hold discussions among members, and specifically dedicated to the organization of gatherings in *Acte I*, does correlate spatially with the outbreak of onsite protest.

This correlation, detailed in Section "Online activity and the outbreak of onsite protest at *Acte I*", provides support for a positive answer to question **Q 1**. While there could be confounding explanations driving the creation of Facebook groups and events for coordinating spatially correlated protests across France at *Acte I*, the most probable explanation points to the impact of these online organizational resources in the success of onsite protest. Section "The consequences of *Acte I*" showed how the diffusion of the movement across Facebook display two different underlying propagation dynamics in phases $\boldsymbol{\Phi}_2$ and $\boldsymbol{\Phi}_3$. We also showed that, within each period, these propagation dynamics obeyed regular laws to surprising precision: power law propagation during $\boldsymbol{\Phi}_2$ and exponential propagation during $\boldsymbol{\Phi}_3$. Power law regimes are usually interpreted as *word-of-mouth* propagation in networks, and have been observed in a multitude of examples addressed in the state of the art. The exponential regime observed during $\boldsymbol{\Phi}_3$ related to the action of information about the movement and its presence online, provided by news outlets after

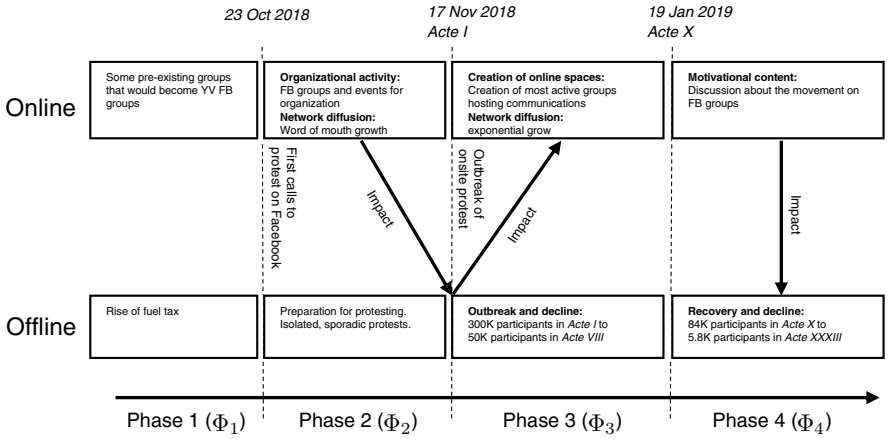

Fig. 12 Online–offline interplay in the Yellow Vest movement: Organizational content on Facebook plausibly impacted the outbreak of protest. In turn, the magnitude of the outbreak of onsite protests changed online political participation. At a later stage, motivational content online was found to be related with changes in numbers of protesters onsite

the successful manifestations of *Acte I* and broadcasted to the ensemble of potential group creators. The abrupt change of regime is the strongest evidence found answering our second question **Q 2**: onsite protest activity can affect the dynamics of the diffusion of the movement online. Our third research question **Q 3** find answers Section Long after *Acte I*: a self-sustained movement". Among all the types of online activity, the attention of users (in the form of likes and shares to post) given to posts mentioning the YV movement can be correlated to short term dynamical changes in weekly protest turnout. This plausibility of the online domain impacting onsite protests offers an interesting hypothesis: once the movement has emerged from claims and demands (to lower fuel taxes), and once organizational resources have been successfully used, it is the motivational resource (attention to the movement itself), that contribute to sustain onsite activity in the most measurable way. This hypothesis outlines relevant future quantitative work on the role of movement identity and sustainability.

Our results are in line with existing research highlighting the importance of social media activity in promoting offline protest participation [59] and the interconnection between these two domains. However, our results further contribute in addressing the mechanisms by which online and offline domains interact, and addresses the dynamic properties of network diffusion of online movements. More importantly, our work establishes clear plausible interplay between online and offline domains, suggesting moving beyond studies of online activity impacting offline activity, to study social movements as a complex co-evolutions between online and onsite dynamics.

In making these claims, however, we are aware of the limits of our study which future research can address. Our results would need confirmation by larger comparative studies to assess if an increase in social media activity is associated with the emergence and consolidation of onsite protests or not, and how this affects online

activity. We would suggest comparing across movements and across countries, to verify if our results are specific to the YVs or remain valid for other movements and in different national contexts, including authoritarian ones. We would also suggest comparing across online platforms, and assessing whether or not other streams of online information, originating from different platforms like Twitter or Youtube, can forecast the outbreak of onsite protests. It should also be noted that even if we collected reliable data on the number of gatherings during *Acte I* and the number of participants for every weekly demonstration, our analyses are based on self-reported data by the YVs (who tend to inflate figures) and by the Ministry of Internal Affairs (who tend to deflate them). Furthermore, the unavailability of cross-sectional data on protests and blockades throughout the duration of the movement is another important limit of the present study. An additional limitation of our study comes from the fact that our data only includes publicly available Facebook groups. Numerous groups are private, meaning that only accepted members can read their contents, and are outside our scope of data collection. Furthermore, it is not possible to estimate the fraction of users that chose to communicate in private with our current collection methods. In addition, Granger causality tests are informative on the usefulness of one time series in forecasting another one, and spatial correlations are informative for the spatial co-occurrence of observations. This does not preclude the existence of confounding variables and delayed mechanisms from providing other plausible explanations for the interplay between online activity and onsite protest. Additionally, Granger causality is not informative about the magnitude of mutual online or offline effects.

The paper is a new step in the study of the interplay between online activity and onsite protests. Our mixed findings invite researchers to go beyond existing research questions that invite investigations into the plausible impact of online activity on onsite protest. Our results advocate for and integrated systems approach to social movements including online and offline domains to understand the consequences that technology may have for (contentious) political participation in the twenty-first century.

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Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

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