

# Conspiracy network in Facebook pages: An Agent Based Model of misleading information in an echo chamber

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**Abstract.** The emergence and development of conspiracy phenomena within the digital space is broadly studied in the literature. The spread of junk or misleading information online is amplified by the increasing use of Social Networks and social media. Specifically on Facebook, there are networks that are specialized in disseminating information from unofficial sources. The aim of this work is to create an agent-based computational model capable of describing and analysing the structure and the development of a conspiracy echo-chamber within Facebook. We map and analyse the development and characteristics of a conspiracy echo-chamber within Facebook, through the study of interactions of articles from unofficial sources within the social network. Then, we explore the variation of the network structure in relation to the variation of certain properties of the articles. A set of preferential sources of information emerge, as if they are somehow being credited by the conspiracy public as references for the dissemination of “informative” content. We also find that there is a polarized bubble of content and users with respect to conspiracy-mindedness. We show that there are pages that have a preferential role within the network as opinion leaders in the conspiracy bubble. Moreover, we also show that there are elements that distinguish many of the analyzed contents, namely political orientation and hate speech. Finally, we highlight that the grounded approach is very useful in the classification process because approaching classification without a-priori categories to be identified in the text make it possible for issues and specific interpretative codes to emerge.

## 1 Introduction

The emergence and development of conspiracy phenomena within the digital space is broadly studied in the literature [1–6]. The spread of junk or misleading information online is amplified by the increasing use of Social Networks and

social media [7–10]. Specifically on Facebook, there are networks that are specialized in disseminating information from unofficial sources. Such pages are linked together in a unique 'sharing' network where specific content bounces around creating an echo effect [11].

The aim of this work is to create an Agent-Based computational Model (ABM) capable of describing and analysing the structure and the development of a conspiracy echo chamber within Facebook. The simulative model designed falls into the category of mid-range models [12]. These models form a middle ground between abstract models describing exclusively general theoretical phenomena and exclusively empirical models [13]. The goal is to create a model that can explain empirical phenomena leading to a general theory [12].

For this reason, the research process consists of two phases: descriptive and experimental. The descriptive phase aims at map and analyse the development and characteristics of a conspiracy echo-chamber within Facebook, through the study of interactions of articles from unofficial sources within the social network. The experimental phase has the output of analyse the variation of the network structure in relation to the variation of certain properties of the articles.

## 2 Theoretical Framework

The present research has three specific theoretical axes: culture diffusion, social influence, and the dynamics of polarization in groups, and it is declined within the empirical macro-phenomenon of information redundancy within the digital space.

### 2.1 Culture diffusion

The sociological literature related to the dynamics of culture dissemination and consolidation is extensive. Here we have chosen to start with the concept of culture as defined by Axelrod [14] who sees the dissemination of culture as the output of a process of mutual influence among social actors who share specific values and distinctive traits. In fact, similar agents will tend to prefer interacting with each other, and as a result a circle of homophily growth is created among them [12]. In this context, the process of interaction between agents plays a key role. Not surprisingly, the starting point of all processes of culture growth and dissemination lies in the exchange and interaction from social actors. In addition, empirical evidence found since Granovetter's studies of weak ties [15] shows that the development of information dissemination and group dynamics are also determined by the quality of the tie that characterizes the exchange between agents [16].

Another sociological concept underlying the process of transmission of culture is the concept of social impact [17] intended as the influence on individual

behavior exerted by the presence of other individuals, which is influenced in turn by the persuasive force exerted by agents, the immediacy and the size of the source of influence [12]. The set of these outlined concepts becomes the basis for the analysis of the phenomenon of group polarization. Group polarization is a phenomenon that arises when its component members move toward a more extreme point in any direction. The three vectors of culture diffusion, relationship and social influence play a key role in this context. Another key element that determines the processes of polarization is the contact with specific persuasive arguments, that is, when a social group is confronted with shared issues and the group members assume a similar system of attitudes in relation to them. According to this theory, since social actors become acquainted with new arguments with respect to a specific theory or they hear other members pronounce arguments that have already been expounded, they consolidate their connection with the group and solidify their beliefs.

## 2.2 Digital space and echo chambers

In the context of the evolution of mass communication systems, a key step of interdisciplinary analysis that is not yet saturated with research activities concerns the field of Social Media and Social Networks. Social systems are so elaborate, complex and ubiquitous in people's daily lives that they are currently a fertile field of research and often a key element to be included within online and offline dimensions of analysis.

In particular, the ubiquitousness of social structures can be found within the daily behavior of social actors to the point of co-occurring in the determination of their own identity. In the collective dimension, the role of social media is fundamental in the determination of collaborative digital networks that can be "weak" and instantaneous, such as affinity networks, but can also structure themselves to the point of constituting themselves as full-fledged social groups.

Therefore, within the social media dimension, the relational potential acquires such importance that the consumer is not only a consumer of messages and content but he or she also becomes a producer and editor, generating a continuous circle of knowledge. In this interpretative frame, the figure of the prosumer is born, that is, the one who producer (producer) and user (consumer) of the media product. The term prosumer was coined in 1980 by American sociologist A. Toffler, while already in 1975 Jean Cloutier elaborated a similar idealtype by calling it self-media: in both cases we refer to the subject's ability to be producer and consumer simultaneously of cultural and media products.

The figure of the prosumer has a large space and is reframed within the digital space [18]. Indeed, it is in the immaterial and collaborative worlds of Web2.0 that it is most difficult to distinguish between producers and consumers, where prosumer hegemony is clearest [19]. The digital prosumer, however, is not to be seen as a particular one-off figure but rather defines any network

user. Each digital actor is also and producer of content, specifically a producer of data. The action of producing a digital content within the web space, in fact, is not necessarily limited to the creation of a specific online multimedia content (post, video, image), but it also concerns simpler and seemingly low communicative value activities such as sharing or retweeting a content, posting a like or geolocating to a specific place. Even choosing to open one website over another means having contributed, even unknowingly, to its management.

### 3 Research Design

The aim of the research is to reconstruct the process by which conspiracy-themed articles are shared by Facebook pages forming a bubble of news from unofficial sources. In particular, a simulative model based on artificial agents was designed and realized. The agents are articles, social pages, websites and users; these interacting with each other make up the “pages-to-articles” network, which is the focus of our investigation.

The simulation project is based on an exploratory survey structured through two research issues.

- **Issue 1:** Some misleading information contents, present in the digital space, have some properties that make them desirable for specific Facebook pages and groups and based on specific characteristics these contents spread within the Social Network. The properties concern respectively: the conspiracy-based content, the intensity of the conspiracy content, the political orientation, incitement to hatred and incitement to fear.
- **Issue 2:** This concerns the analysis of the impact of the content of the articles on the topology of the eco chamber through the simulation model.

Based on these two items, the simulation model has a dual purpose: descriptive and experimental. The descriptive phase aims to reconstruct and analyze the development and characteristics of a conspiratorial echo chamber within the Facebook Social Network by simultaneously exploiting the computational social simulation and Social Network Analysis. The experimental phase, on the other hand, has the goal of analyzing the variation of the network structure in relation to the variation of some properties of the articles.

Under these assumptions, the research was structured in three tasks:

1. Survey data;
2. Development of the ABM simulation;
3. Experimentation.

The output of the first task was to map and analyze the echo chamber network of the conspiracy movement in Facebook through the interactions of specific content within the social network. The second task was aimed at the Analysis and classification of the articles and sources detected, and construction of the simulation model based on the features identified in the classification. The third

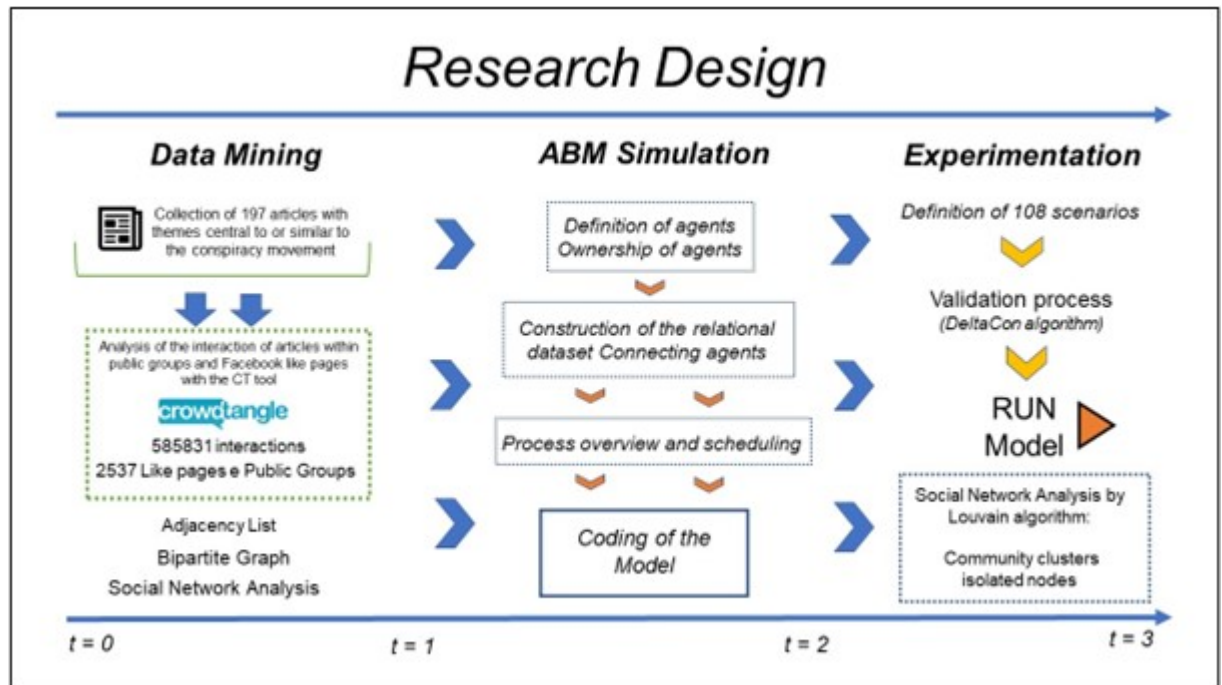


Fig. 1. Our research design phases

task was Experimentation of the simulative dynamic network model. The last stage was pointed out, through the SNA, how the topology of the echo chamber varies. The simulation was organized in two steps: in the first step we ran the model, experimenting with various parameters, until the network obtained from the simulation was 'similar' to the empirically determined one (validation phase). Next, the simulation model was run using scenarios (combinations of item and page properties) and observing greater or lesser cohesion of the output networks.

## 4 Data Mining

In the first phase of the research, an analysis of digital footprints was carried out with respect to Italian counter-information sources identified through a qualitative observation phase of the interactions and content shared within a set of public groups on Facebook. In this regard, 197 articles have been selected on the basis of their content in line with the typical themes of the conspiracy movement. Subsequently, the interactions of each article within Facebook were detected through the Social Network Analysis tool. This phase was important both to circumscribe the ecosystem of conspiracy-minded public pages and

groups and to identify the posts with most interactions.

Some empirical evidence emerges from the preliminary analysis:

1. there are Facebook sources that only share conspiracy-based content;
2. these articles to be of interest with respect to the pages present specific contents;
3. the contents found come in turn from sources specialized in the dissemination of conspiracy information.

The set of data collected and the processing carried out made it possible to identify the main units (agents) at the basis of the construction process of the echo chamber:

1. Websites or the sites (blogs, information portals, online newspapers, etc.) that produce and contain the articles identified.
2. Articles, which are collected in the first phase of the research and have the characteristic of presenting contents of information.
3. Pages, including the pages and public Facebook groups that have shared the articles.
4. Users, who interacted within Facebook with the articles.

## 5 ABM Simulation

Based on the data collected in the Data Mining phase, the simulation model was designed and realized in two operational tasks: agent definition, model coding design, and algorithm definition.

### 5.1 Agents

The data collected was used to build a relational dataset in which the following agents are connected: Articles, Websites, Pages and Users (fig. 2).

In detail, the four types are structured as follows: the web sites are connected only with the articles, the articles are connected with the Web sites and with the Pages, the pages are connected with the articles and with the users and finally the users are connected exclusively with pages. Specifically, the Articles dataset was constructed by inserting all the articles identified in the first phase of the research classified in their content in relation to the following interpretative categories <sup>4</sup>: 1) contents, the presence / absence of conspiratorial content; 2) intensity of the content on a scale from 1 to 5; 3) issue, or the conspiracy narratives present in the article; 4) political, if the article is politically aligned; 5) political orientation, what political orientation does it present, 6) incitement to hate, if it presents characteristics of incitement to hate; 7) incitement to fear, incitement to fear.

<sup>4</sup> The categories identified emerged from an analysis of the content carried out on the text and title of the articles collected

The websites dataset was composed by inserting the following information for each website identified: sum of interactions, count of articles, fame index and exclusivity. Sum of interaction indicates the total sum of the interactions that the contents from that site have had within Facebook, while count of articles is a value that indicates the number of articles collected from that website. These two values together make up Fame index, that is a synthetic index that expresses when a website is popular within the detected echo chamber. The index was obtained by normalizing the indicators, heating them between 0 and 1. The standardization process was carried out with the elementary indicators min-max,  $Z = (x - \min(x)) / (\max(x) - \min(x))$ , aggregated to the arithmetic mean. Finally, Exclusivity is a value ranging from 1 to 5 which indicates the exclusivity of conspiracy-inspired content within a web site. Finally, User is made up of User Id or a label that identifies the user, Content, the content of the product comment for each Id Pages page.

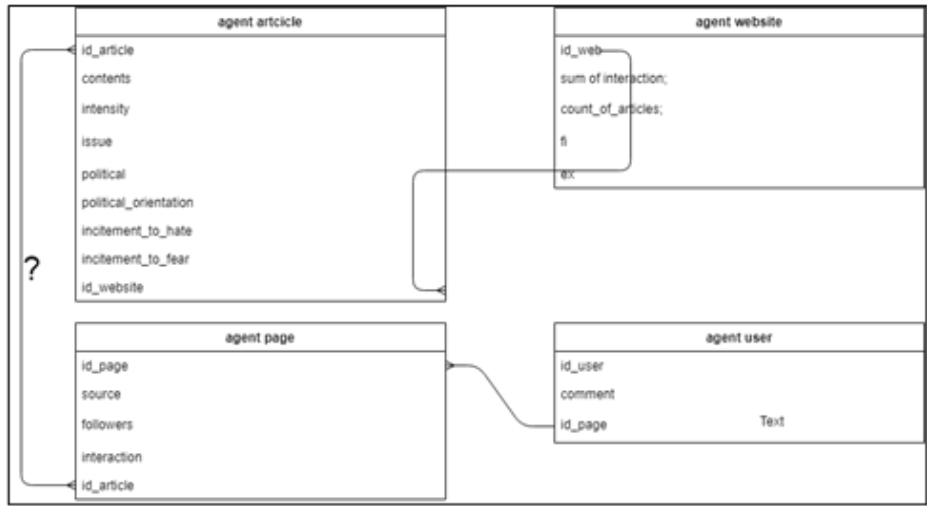


Fig. 2. Our research design phases

### 5.2 Simulation model

The purpose of the simulation is to reconstruct the pages vs. articles. In the simulation we had to create links between pages and articles. This must be done using the properties of the articles, websites, pages and users taken from the survey. In the start phase, the links between pages and articles are not loaded since that type of network represents the output of the simulation. The values of these properties are combined in the simulation with weights that determine

whether the value of a certain property increases or decreases the probability that a certain article page pair will be created or not. We call this set of weights scenario. The scenario is, in practice, our theory of how the page-article network is formed.

The simulation is organized according to a flow in 4 phases. In detail, in a first phase a page is selected through a stochastic lottery based on the properties of the page. Subsequently (phase 2) a pool of articles is created, again through a stochastic lottery based on the properties of the articles; each property is weighted, each issue has its own weight and the weights are called scenarios. Each article in the pool is then associated with the websites to the article-web pair and a score is assigned, again on the basis of the scenario (phase 3) and finally (phase 4) if an article-web pair has a score above a certain threshold then binds to the page.

In the descriptive phase, the built network is loaded starting from the data collected in the preliminary stages of the research and reorganized within the relational database described.

## 6 Experimentation

In the course of the simulation, we can carry out experiments, changing Scenario. A scenario consists in varying two components:

1. the probability that a page is selected in the process that creates a link between the page and the article. The probability  $p_i$  that page is calculated considering the distribution of followers and interactions. For this component, the scenario has only one parameter, which is the maximum probability of each page being selected.
2. The probability that an item is selected in the item pool. It is calculated on the basis of the properties of the article, weighted according to a scheme.

### 6.1 Definition of Scenarios

The issue classification phase of the articles described in the Agents section was carried out on the basis of a qualitative content analysis of the articles carried out with R's RQDA package. Qualitative content analysis from a methodological point of view falls within the Grounded Theory framework since the identified dimensions emerged directly from the research field (cite). Specifically, the following interpretive categories emerged: "Big\_Pharma" "NWO" "Qanoon" "5G" "Bill Gates" "Chinese economic boom" "Corona Fake", "Health\_dictatorship", "Ecomafia", "American\_elections\_modified", "Medical\_error", "No\_Vax", "No-Mask", "Reductionism historical ", "Chemtrails" "UFO". In addition, content analysis shows that some articles have politically oriented content and elements of hate and fear incitement.

Some elements connoting specific classic conspiracy movements such as theories about climate manipulation (5G, Chemtrails) or pharmaceutical companies'



speculation to the detriment of public health (No\_Vax, Big Pharma Medical error) emerge from the classification of the Issue. Some Issues cover content segments in line with the pandemic phase "Corona Fake" "Health\_dictatorship" "No mask" "Medical error" while others relate to the themes of the QAnon movement and the new world order (NWO, Bill Gates, American\_elections\_modified).

Therefore, based on the content analysis, and with the support of the literature on the topic of conspiracy movements, thematic profiles were defined on the basis of which "weights" were assigned to be given to the stochastic lottery underlying the simulation algorithm, as it is shown in the table 1

Issue	Default Weight	Covid Conspirationism Weight	QAnon Weight	Traditional Conspirationism Weight	Health Weight	Enviroment and Climate Weight
Big_Pharma	2	4	3	4	4	4
NWO	2	3	4	2	1	2
Qanoon	2	2	4	2	2	1
5G	2	3	2	4	3	4
Bill Gates	2	4	3	2	3	4
Chinese economic boom	2	4	1	1	1	4
Corona Fake	2	4	2	1	3	1
Health_dictators hip	2	4	3	1	3	1
Ecomafia	2	1	1	1	1	4
American_electi ons_modified	2	2	4	1	1	1
Medical_error	2	3	1	1	3	1
No_Vax	2	4	3	4	4	2
NoMask	2	4	1	1	3	1
Reductionism historical	2	1	1	3	1	1
Chemtrails	2	2	2	4	2	4
UFO	2	1	1	4	1	1

Table 1. Thematic profiles

The definition of scenarios for the experimental phase was organized by considering four vectors: profiling, hate incitement, political orientation, and message intensity. Specifically, each for each scenario we defined:

1. the presence absence of incitement to hatred and fear by intending them with the values 0/1;
2. the political orientation by distinguishing left right or neutral;
3. the intensity of the message, low (1), medium (3), high (5). Each profile identifies 18 scenarios for a total of 108.

## 6.2 Validation

In this kind of simulation, the main problem modeling is the quantitative definition of the parameters. In fact, if on the one hand the structure of the algorithm is deduced from theoretical considerations, the quantitative definition of the parameters must derive from some comparison between networks obtained from the simulation and the network observed empirically. In our experiment, it needs to implement a network comparison metric. We have chosen to use a metric called DeltaCon . To analyze the parameter space we used a genetic algorithm, as into Automatic Tuning of Agent-Based Models Using Genetic Algorithms, Benoît Calvez and Guillaume Hutzler.

The results shown in this paper were obtained by minimizing the DeltaCon by varying the set of parameters described in the table 1. The optimization results are also provided.

## 7 Results

We performed a simulation that relates various parameters (violence in the articles, presence of political orientation and issue) with two statistics taken in the networks:

1. the number of communities,
2. the number of nodes without connections.

The number of communities is computed by a multi-level algorithm. We implement the multi-level modularity optimization algorithm for finding community structure [20]. The algorithm is sometimes known as the "Louvain" algorithm. The algorithm is based on the modularity measure and a hierarchical approach. Initially, each vertex is assigned to a community on its own. In every step, vertices are re-assigned to communities in a local, greedy way: in a random order, each vertex is moved to the community with which it achieves the highest contribution to modularity.

When no vertices can be reassigned, each community is considered a vertex on its own, and the process starts again with the merged communities. The process stops when there is only a single vertex left or when the modularity cannot be increased any more in a step.

The main results are showed in table 2 and table 3.

	Community					Isolated				
	1	2	3	4	5	1	2	3	4	5
Health	2.11%	2.01%	2.02%	1.92%	1.88%	0.26%	0.21%	0.22%	0.21%	0.18%
Traditional Conspirac ionism	2.11%	2.04%	2.01%	1.96%	1.89%	0.28%	0.24%	0.19%	0.19%	0.21%
NWO	2.10%	2.05%	2.00%	1.97%	1.94%	0.29%	0.24%	0.21%	0.24%	0.18%
Default	2.10%	1.97%	2.02%	1.96%	1.91%	0.28%	0.22%	0.20%	0.20%	0.17%
Environmen t and Climate	2.09%	2.12%	2.01%	2.01%	1.98%	0.25%	0.24%	0.22%	0.21%	0.19%
Covid Conspirac ionism	2.02%	1.96%	1.91%	1.89%	1.90%	0.21%	0.20%	0.20%	0.17%	0.16%

**Table 2.** At the end of the simulation, we take two statistics: the average of the communities that have formed within the article-page network, and the number of nodes that have remained isolated. These two numbers are shown as a ratio between them and the number of nodes present in the network. This table evaluates the simulations where the fact that an article was politically oriented 'to the left' played a role. The importance of violence in creating links between nodes and pages ranges from a value of 1 to a value of 5

	Community					Isolated				
	1	2	3	4	5	1	2	3	4	5
Health	2.18%	2.04%	2.01%	1.89%	1.90%	0.30%	0.24%	0.23%	0.19%	0.13%
Environment and Climate	2.14%	2.06%	2.01%	2.02%	1.95%	0.31%	0.20%	0.23%	0.19%	0.18%
Traditional Conspirac ionism	2.13%	2.03%	2.03%	2.00%	1.98%	0.26%	0.22%	0.19%	0.19%	0.19%
Covid Conspirac ionism	2.11%	1.96%	1.92%	1.92%	1.96%	0.31%	0.22%	0.19%	0.19%	0.17%
NWO	2.10%	2.10%	2.01%	1.97%	1.92%	0.28%	0.27%	0.19%	0.18%	0.15%
Default	2.05%	2.03%	2.02%	1.94%	1.98%	0.28%	0.23%	0.21%	0.14%	0.22%

**Table 3.** Similar to table 2, with the difference that evaluated politically oriented is 'to the right'

	Average of rateo_comunity					Average of rateo_isolati				
	1	2	3	4	5	1	2	3	4	5
Health	2,21%	2,05%	1,95%	1,89%	1,98%	0,39%	0,21%	0,20%	0,21%	0,18%
NWO	2,15%	2,11%	1,92%	1,97%	1,86%	0,29%	0,24%	0,19%	0,19%	0,15%
default	2,14%	2,11%	1,97%	1,88%	1,84%	0,26%	0,26%	0,25%	0,17%	0,13%
Traditional Cospiracionism	2,03%	2,03%	2,00%	1,91%	1,96%	0,23%	0,27%	0,20%	0,19%	0,22%
Covid Cospiracionism	2,02%	1,95%	1,98%	2,03%	1,92%	0,25%	0,23%	0,18%	0,21%	0,15%
Environment and Climate	2,00%	2,07%	2,01%	1,97%	2,04%	0,27%	0,25%	0,22%	0,26%	0,27%

Table 4. Neutral political orientation

	Average of rateo_comunity					Average of rateo_isolati				
	1	2	3	4	5	1	2	3	4	5
Health	2,16%	2,03%	2,00%	1,90%	1,91%	0,30%	0,22%	0,22%	0,20%	0,16%
NWO	2,11%	2,08%	1,99%	1,97%	1,92%	0,29%	0,25%	0,20%	0,21%	0,16%
Traditional Cospiracionism	2,11%	2,03%	2,02%	1,97%	1,94%	0,26%	0,24%	0,20%	0,19%	0,20%
Environment and Climate	2,09%	2,09%	2,01%	2,01%	1,98%	0,28%	0,23%	0,22%	0,21%	0,20%
default	2,09%	2,02%	2,01%	1,94%	1,93%	0,28%	0,23%	0,21%	0,17%	0,18%
Covid Cospiracionism	2,06%	1,96%	1,92%	1,93%	1,93%	0,26%	0,21%	0,19%	0,18%	0,16%

Table 5. Explicit incitement to hatred

	Average of rateo_comunity					Average of rateo_isolati				
	1	2	3	4	5	1	2	3	4	5
Covid Cospiracionism	1,89%	1,89%	1,85%	1,84%	1,86%	0,11%	0,11%	0,11%	0,11%	0,11%
default	2,00%	1,92%	1,92%	1,89%	1,86%	0,11%	0,11%	0,11%	0,11%	0,11%
Environment and Climate	1,93%	1,98%	1,90%	1,94%	1,89%	0,11%	0,11%	0,11%	0,11%	0,11%
Health	1,88%	1,92%	1,92%	1,79%	1,86%	0,11%	0,11%	0,11%	0,11%	0,11%
NWO	2,03%	1,92%	1,87%	1,86%	1,87%	0,11%	0,11%	0,11%	0,11%	0,11%
Traditional Cospiracionism	1,96%	1,92%	1,89%	1,90%	1,86%	0,11%	0,11%	0,11%	0,11%	0,11%

Table 6. No explicit incitement to hatred

## 8 Discussion

The results OF the simulation runs, described in the previous paragraph, lead to a series of considerations about the elements that influence the structure of the conspiracy bubble within the Facebook Social Network.

With respect to the most aggregating themes from the experiment conducted, it emerges that there are certain themes that determine group cohesion more than the "Default" profile including "Health" "NWO" and "Covid Conspiracionism." However, it is interesting to note that the results of the simulation run show that the aggregating factors that determine bubble structuring are: message intensity, political orientation and incitement to hatred/fear.

With respect to message intensity, it is shown that in the range 4-5 the average community rate decreases, along with it the number of isolated nodes within the network (see the tables 2,3,4,5,6).

As regards political orientation from tables 2,3,4 it can be seen how the definition of specific political orientations, across the different thematic profiles, significantly changes the structure of the network, in fact regardless of the type of political orientation (right or left) the structure of the network with respect to neutral scenarios except for the default profile which remains constant at in all three run models.

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Finally, the incitement to hatred and fear turns out to be a determinant with respect to group cohesion, compared to the sample analyzed: in fact, a significant

variation in the levels of group aggregation emerges when the shared content contains elements of incitement to hatred (in tables 5,6).

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