Social Identity Model of Protest Emergence (SIMPE), an agent-based model of national identity and protest mobilisations

ODD+D protocol v.2

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1. Purpose

To explore the impact of national identity polarisation on protest emergence. To evaluate the potential impact of filtering algorithms on information receipt and subsequently the diffusion of information and opinion dynamics. This model is interested in protest emergence around the Catalan secessionist movement. Data from the Catalan Centre of Opinion Studies (CEO, 2022) has been used to inform some of the model parameters. This has allowed to create two separate model versions, abstract and empirically-informed.

2. Entities, processes, and scales

There are two type of entities in the model: The agents and the environment. The agents represent people, and the environment represents their social networks, online and offline.

2.1 The environment

The environment provides the social space within which agents act and interact. It consists of a weighted multilayer multiplex network representing online and offline social networks of a given population. There are two layers corresponding to online and offline social networks of a given population. The nodes are represented as u and v. The links between the two nodes signify a relationship between the pair of agents (u,v). These links or ties are weighted in both layers or dimensions. This is to reflect various degrees of social influence agents can have on one another. It is a multiplex network since the nodes on each layer are representing the same entity, unlike interconnected networks (Kinsley et al., 2020). Also, the interlayer edges link

nodes representing the same individual instead of different individuals across layers (Gómez et al., 2013). See Figure 1 for details of the network environment.

The offline social network is the base layer. The offline network is where agents act, in the form of attending a protest whereas the online layer is where agents get exposed to information and change their opinions. A small world network topology is used (Watts and Strogatz, 1998). The degree distribution for this network, that is the average number of connections people have in real life, was obtained from population data in Spain. The average number of friends is 27 including family and friends (see Lubbers et al., 2019).

The online layer represents social networks in social media platforms. A scale-free network topology Barabási-Albert (Barabási, 2009) was used since online networks have been shown to have a very skewed degree distribution where a few people are very well connected while the majority have few connections (Piedrahita et al., 2017; Kwak et al., 2010). Social media platforms have greater degree distributions than offline networks. However, Dunbar and colleagues found that for Facebook and Twitter networks, the average number of friends matched the Dunbar number of 150 (Dunbar et al., 2015). This number has been scaled down to 45 due to the sample size.

Not all nodes from Layer 1, offline networks, are present in Layer 2, online networks, since not every individual is present or uses social media platforms, see Node A in Figure 1. The ratio of online to offline nodes was obtained from social media use in Spain (Kemp, 2021). That is eighty percent, meaning that 500 agents will not have an online presence. The number of agents with a corresponding online account is fixed throughout the simulation.

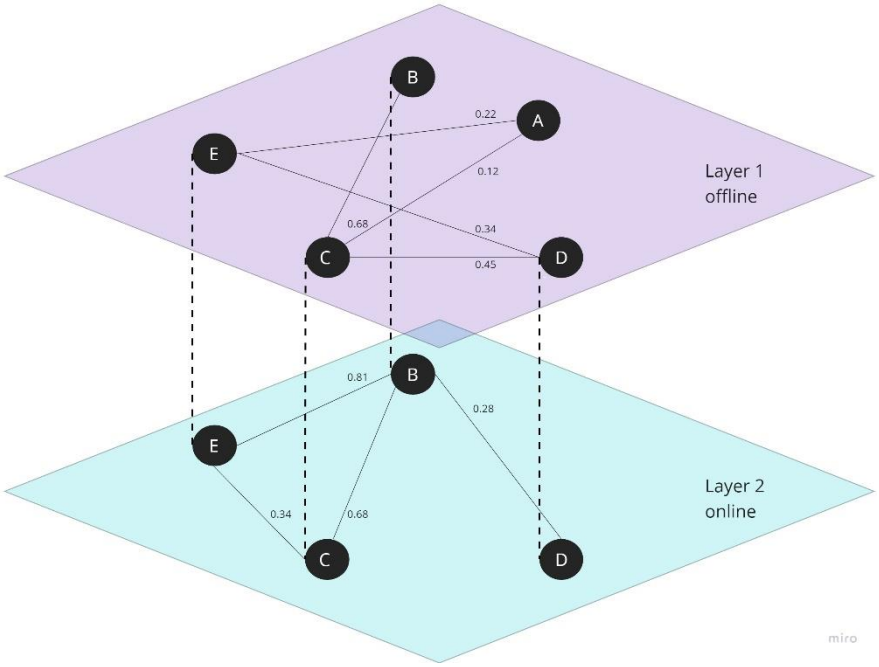

Figure 1: The simulation environment. Dashed lines represent interlayer connections and solid lines represent intralayer connections. (Layer 1) Offline social network with four nodes and three edges carrying different weights. (Layer 2) Online social networks composed of three nodes since one of the nodes does not have an online account.

Agents will form new social relations and dissolve previous ones based on random probability. The rewiring probability captures the process of social network changes and can be adjusted in the model to explore the extent to which adding and removing connections affects national identity polarisation and protest emergence. Ten percent of the agent population will drop a tie and make a new one. The chosen tie to drop can either be too dissimilar or with low social influence, given by the tie weight. In other words, the agent will be slowly favouring the ingroup members or like-minded agents over dissimilar or outgroup members (Bakshy et al., 2012; Boutyline and Willer, 2016). Similarly, for adding a new tie agents will select someone connected to their closest tie in terms of social influence (Axelrod, 1997; Abrams et al., 1990). This action is in place to recreate the cultural homogeneity found in society.

Beyond the network topologies, there are two initial social network scenarios, Figure 2, to test the effect of social networks and echo chambers on national identity polarisation and protest mobilisation. The network topology remains fixed whereas the national identity composition of the nodes changes. The random network scenario assumes that individuals make social connections at random, regardless of how similar or dissimilar the new connection is in terms

of national identities. As a result, we can test the effects of social influence and social cohesion for national identity polarisation and protest mobilisation. On the other hand, the homophilly-based initial social network setting assumes that individuals do have a preference when befriending others whereby they will be more likely to befriend those they deem similar to themselves (see Flache and Macy 2011; Flache et al. 2017). Similarity is this context refers to the overlap between national identities, adapted from bounded confidence opinion models (Deffuant, Amblard et al. 2002). In this scenario, at least ninety percent of ties have similar national identities to *i* since we're interested in studying the direct effect of homophily on national identity dynamics and protest mobilisation.

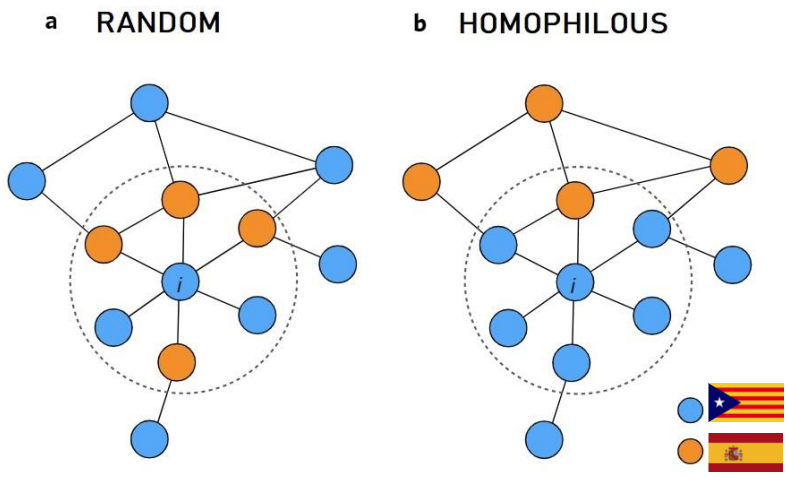

Figure 2: Initial social network scenarios. A) Random where ties are made ignoring national identity similarity. B) Homophilous where ties are made taking into account national identity similarities. Figure adapted from Lee, E., Karimi, F., Wagner, C. et al. (2019) Homophily and minority-group size explain perception biases in social networks, *Nature Human Behaviours*, 3, 1078–1087.

Moreover, this model takes on the task to create two information filtering scenarios, random and selectively exposed, to address these contested findings about the effects of sorting algorithms or filter bubbles present on social media platforms. The random information scenario represents a balanced media environment where individuals have equal probabilities of receiving national identity supportive and national identity discrepant information. Alternatively, the presence of social media filter bubbles agents simulates an unbalanced media

diet whereby individuals get primarily exposed to information that is similar to their national identities, within the bounded confidence threshold of similarity discussed later.

Lastly, the initial number of protesters at the start of the simulation captures the critical mass theory of collective action and can be adjusted. The protesting opportunity abstractly represents the opportunities agents have in the simulated society to join a protest which can also be adjusted.

2.2 Agents

The agents represent people (N= 2,500). They are dynamic entities that can create new ties and dissolve old ones, share information, update their national identities, and engage in protests following discussions with other agents and the environment. Agents are assigned a number of ties in their offline and online social networks with different weights given by their network topologies as discussed in section 2.1. Agents are characterised by national identity, social engagement, certainty of opinions, grievances, and cost of protesting. Specific details about the agent's attributes/characteristics can be found in section 4.1.

Agents get exposed to information, from the media and their social networks. While engaging in these discussions, agents may decide to share the information with their networks and may decide to change their national identity. Following this, agents decide whether or not to engage in protesting. Agents are also socially aware and can sense the number of ties who are about to protest or currently protesting. They use this knowledge for deciding whether or not to engage in such protests. A state parameter counts the number of agents actively participating in a protest each time step.

Agents evaluate their environment through self-categorisation. Agents categorise the ties they have into ingroup, and outgroup members based on how similar their national identity are. Following the principle of homophily, agents consider the national identity of their social networks, online and offline. This principle guides the information sharing and protesting

decisions. Moreover, when the majority of the agent's online ties are ingroup members, fall within the 0.5 similarity threshold, we speak of homophily. Alternatively, we have mixed views in the agent's environment. This is because this model is interested in measuring the effects of online echo chambers, composed of seventy percent similar ties, have on national identity polarisation and protest mobilisation.

2.3 Temporal resolution

Time in this model is treated as a discrete variable and it is abstract. This means that it advances one unit or step once all the agents have completed their actions or decisions, in line with previous models (see Epstein 2013; Deffuant et al. 2000).

2.4 Process overview and scheduling

There are three key behaviours in SIMPE, information diffusion, national identity change, and protest mobilisation, captured in three separate decisions that each agent has to make every step of the simulation.

2.4.1 Information diffusion

The start of the simulation begins with an agent, being selected at random, that must decide whether or not to share the information received. The original agent receives information from the media, however if they decide to share, the network connections of this agent will receive information from social connections instead of the media. As agents engage with other agents on online discussions they get exposed to information. The engagement parameter determines describes the likelihood of an agent socialising with another agent. It is drawn from a random normal distribution.

Regardless of whether the social media filter bubbles are enabled or disabled, agents evaluate the information they receive on the basis of its alignment with their views. Agents evaluate the

information on how similar/dissimilar it is to their own national identity. This similarity threshold, $0 \leqslant e \geqslant |0.5|$, follows the principle of bounded confidence opinion dynamics models (Deffuant et al. 2005; Jager and Amblard 2005; Flache and Macy 2011), that if met, information is considered similar.

Agents also account for their neighbour's opinions when deciding whether or not to share information. if seven out of ten ties share similar national identities, within the similarity threshold discussed previously, we consider to be homophily or group consensus around national identity. Otherwise, the agent is in a group of people with mixed national identities. This is crucial since the agent's likelihood of sharing information that contradicts the group's national identity consensus is smaller if there is a majority view regarding national identification. The value chosen to represent this likelihood of sharing information disagreeing with the majority's national identity is twenty percent, to capture the Spiral of Silence process developed by Noelle-Neumann (1974).

Once the agent has evaluated both aspects, they will decide whether or not to share the information. Should they choose to do so, the information is shared with the agent's ties, online and offline, triggering their own evaluations of the information they have just received. There are two communication regimes if the agent decides to share the information received. Offline social networks follow a one-to-one communication, as described in previous models (Keijzer et al. 2018; Axelrod 1997b) where agents would interact with one person at the time. Conversely, online social networks follow a one-to-all communication since online actions can be viewed by every follower and friend a person has. Then, the agent would move on to the next process. Should the agent choose not to share the information, they move on to the next process, national identity change, straight away.

2.4.2 National identity change

When agents encounter information, they also evaluate it against their own beliefs to decide whether or not to update their national identity. There are two separate initial distributions of national identity, an abstract and an empirically-informed (see Section 4.1). Agents' decision

to change their national identity is based on three elements: national identity similarity, social influence, and certainty.

Agents will evaluate how similar the information is to their own beliefs to see if it is below their bounded confidence threshold. This is the same evaluation they did for the sharing decision. Besides national identity similarity, agents' factor in their ties' social influence when deciding to change their national identity. Agents will check the source's origin to obtain the social influence of the sender. If the information was received from a tie, agents compute the social influence, represented by the weight of the tie, $0 \leqslant W_{i,j} \geqslant 1$.

The last component of the agent's decision to change their national identity is certainty. This parameter represents a person's stubbornness about an attitude, how certain or uncertain their views on something are meaning some agents will be more reluctant than others to change their national identities. Unlike previous models of opinion dynamics, this parameter is heterogeneous across agents to capture the diversity of commitment to one's national identity.

If the result of the calculation is below a threshold, 0.5 like on previous opinion dynamics models, the agent will change their national identity. Agents will update their national identity accordingly depending on its (dis)similarity with their own. If the difference between the agent's national identity and the information's is smaller than 0.5, they will incorporate that difference to their current opinion. Alternatively, if the difference between the agent's national identity and the information's is greater than 0.5, they will subtract the difference between their national identity and the information's from their current national identity (see Section 4.2.2). Modelling national identity change this way allows for positive and negative social influence.

Updating the agent's national identity will affect the homophily parameter as it may alter the ratio of ingroup-outgroup ties. Agents can only update their national identity once per step, regardless of the number of information they have received. After the national identity and homophily parameters have been updated accordingly, the agent will move on to the next step of protest decision-making. Should an agent decide not to change their national identity, they move on to the next step, protest decision-making, straight away.

2.4.3 Protesting process

Set at the start of the simulation, the initial number of protesters aims to capture the critical mass theory of collective action (Spier 2017; Macy 1990). Secondly, the protesting opportunities are an abstract representation of the potential for a protest taking place and provide agents with an opportunity to protest. Agents can then choose, based on the three mechanisms whether they want to join the protest or remain silent (not protesting). Once an agent has decided to protest, they cannot revert back to silent.

Previous models have ignored the role of social influence and group identities when it comes to protesting, unlike here where agents compute not just their own grievance perceptions but that of their ties. These grievances are based on their national identity and only ingroup members grievance perceptions are computed into the protesting threshold to account for the effects of social influence.

The second parameter will be protesting costs, which are a deterrent for agent's protesting. This value is heterogeneous across agents while fixed throughout the simulation. Moreover, agents also consider their social networks protesting states, as a neighbourhood protest participation parameter, to evaluate how many of their ties are protesting or silent. This is based on the critical mass theory whereby people need to see a certain number of others protesting before deciding to join such protest. These values are both multiplied by a constant, h, to normalise the weight of social influence in the decision to protest.

3. Design concepts

3.1 Theoretical and Empirical Background

The social identity theory framework provides a theoretical background for the ABM. The theory asserts that individuals develop a social identity by comparing themselves to others and identifying those similar to them. Ingroup and outgroup members are created as result (see

Tajfel, 1972; Turner, 1999). This distinction between individuals has consequences for collective action participation as well as for opinion dynamics.

In the case of opinion dynamics, the agent's network composition will affect their likelihood of sharing contrary information within their group. Individuals tend to refrain from sharing information that is not in line with their neighbour's opinions (Kumpel, 2015). The "spiral of silence" is the term used to describe this phenomenon where an individual will be less inclined to share information with their network if they know that the information is contrary to the network's general beliefs or ideas (Noelle-Neuman, 1974; Dubois and Szwark, 2018).

However, group identification has consequences for national identity change. People tend to be more persuasive if they were considered to be similar to oneself, part of the ingroup (Turner, 1991). This suggests that when individuals discuss information with like-minded others, they will be more easily persuaded in favour of that information than if they were discussing the same information with outgroup members. This is reflected in the national identity change process in the form of homophily check and social influence additional values.

At the individual level agents are characterised by a social identity, in the form of national identity since we are modelling an independence movement. Although a core value that defines group membership, national identity is also treated as an opinion and therefore susceptible to change. Social identity in this model has a dual function: group membership identification and collective action promoter. Survey data from Catalonia (CEO, 2022) on the issue domain of national identity has been used to inform the distribution of national identities in the model.

Halberstam (2014) observed differing patterns of political opinion diffusion online depending on the group size and homophily levels of the social network. By homophily Halberstam (2014) was referring to the number of like-minded individuals in a given group. The greater homophily, the greater the bias towards supportive information which reinforces pre-existing beliefs while limiting exposure to alternative sources/people (see Bakshy, 2012; Sphor, 2017; Bliuc et al, 2020).

Social media platforms selectively expose users to certain types of information through their built-in sorting algorithms (Flaxman, 2016). These filter bubbles sort and select information based on the user preferences and previous activity (Pariser, 2011). Filter bubbles are problematic as they limit the user's exposure to cross-cutting content, content that might not agree with the user's viewpoint. As a result, users will be more frequently exposed to information supporting their beliefs and in line with their interests (Mäs and Bischofberger, 2015) rather than challenging their views. The model will run experiments with and without the filter algorithms being active to determine whether opinion dynamics and subsequently protest emergence change as a result.

Another attribute shared by agents is stubbornness or uncertainty about their opinions. This has been found a strong predictor of opinion change in previous models of opinion dynamics (see Deffuant, 2000; Hegselmann and Krause, 2002; Deffuant, 2006). When an individual disagrees with their group this conflict produces uncertainty, and the social influence process begins as to alleviate such uncertainty (see Turner, 1991; Moscovici, 1976). This parameter will be drawn from a random distribution due to the lack of empirical data available.

To implement these social influences in the ABM, social ties are created between agents, and they are weighted to represent different social influence exerted by different agents. Agents factor in their neighbour's grievance perceptions as well as their social influence when deciding whether or not to participate in a protest. In addition, agents observe who from their ties is protesting or remaining silent when deciding whether or not to join a protest themselves.

The configuration of the social network ties, online and offline, may affect the national identity dynamics as well as protesting decisions. The network degree distribution for both online and offline networks is taken from empirical data of various sources (see Section 4.1). In that way, a more accurate picture of real-life social networks can be obtained. The influence of the social environment is based on findings suggesting that the presence of others might increase participation in protests (Rojas and Puig-i-Abril, 2009; Linssen et al., 2018).

Agents also differ in ‘tendency’ to be active, given by their grievance perceptions as well as that of their ingroup neighbours’. This idea is inspired by Joshua Epstein’s (2013) Agent Zero model. He proposed a simulation model of ethnic civil violence. Each of the agents have a personal and a group threshold to become active or attack outgroup members. His theory is based on fear inducing stimulus causing agents to activate. His proof of concept showed how individuals might not need to be directly exposed to outgroup members in order to perceive them as a threat and activate. This model uses the same principle as Epstein’s (2013) for the protesting decision in the form of individual and group grievance perceptions.

3.2 Heterogeneity

Agents include heterogenous characteristics: national identity, uncertainty, engagement, grievance perceptions, costs of participating. The social networks being modelled will be a multilayer multiplex network with 2 layers with different topologies. A small world network (Watts and Strogatz, 1998) for the offline social network and scale-free Barabási-Albert (Barabási, 2009) for the online.

3.3 Interactions

Agents interact in several ways:

Agents interact with information through their social networks and their online feeds which will affect their exposure to information and thus their sharing decision, national identity change and protesting. When agents decide about sharing information, they evaluate whether or not to change their national identity based on the information received and the sender. Agents factor in their social networks in the form of social influence.

Agents interact with one another when it comes to protesting. They account for the agent’s ingroup members grievances as well as their own grievances. Meaning that the agents’ tendency to be protest is dependent on their friends’ tendency to protest as well as who else in their social network may be protesting and the costs associated with protesting. Agents categorise their social network into ingroups and outgroups and are more likely to make new

ties with similar agents and break ties with dissimilar agents. Agents surrounding themselves with only similar others or ingroup members will affect all the above interactions.

3.4 Stochasticity

Agents' decisions are based on probabilistic choices represented by thresholds and therefore include some stochasticity. The initialisation of agents' characteristic can be found on section 4.1 detailing the sampling procedure for all the parameters.

3.5 Emergence

There are four emergent properties in the model. First, the information cascades generated by agent's sharing activities and interactions with one another. Second, the national identity dynamics in the form of various national identity distributions as a result of multiple agent interactions. Third, protesting. Lastly, network re-wiring via formation and dissolution of ties between agents.

4. Details

4.1 Initialisation

Agents are generated for each social network layer. Attributes are assigned as follows:

Attributes	**Assignment**
National Identity (-1,1)	Two initial distributions. Abstract-theoretical following a random normal distribution ($\bar{X}= 0$ and $\sigma = 0.40$) and a theoretically-informed sampled from the distribution in the CEO Barometer Survey (2011) ($\bar{X}= 0.45$ and $\sigma = 0.52$).
Grievances Perception	Randomly sampled: Normal (mean=0, STD=0.4)

(-1,1)	
Certainty (0,1)	Randomly sampled: Normal (mean=1, STD=0.5) (see Deffuant et al., 2000)
Cost of participation (0,1)	Randomly sampled, Normal (mean=1, STD=0.5)
Engagement (0,1)	Randomly sampled, Normal (mean=1, STD=0.5)

The general model parameters, set at the start of the simulation are as follows:

Parameter	**Assignment**
Information	Representing the media's reporting about the secessionist movement. Follows a random normal distribution (-1,1) ($\bar{X}$= 0 and σ = 0.40).
Social Networks	Two social network setup scenarios. Random; Homophily-Based
Social Media	Two social media filtering scenarios. Filter Bubble On; Filter Bubble Off
Rewiring probability	Probability of making a new tie each step (0,0.5)
Initial protest size	Proportion of agents protesting at the start of the simulation (0,50)
Protesting Opportunity	Opportunities for agents to join a protest (0,0.5)
s	National identity similarity threshold (0.5)
d	National identity change constant (0.01)
h	Weight of social networks for protesting constant (0.01)

4.2 Sub models

4.2.1 Information sharing process

At the start of the simulation agents encounter information, either via their friends or via online feeds. Agents calculate their similarity threshold, National Identity Similarity (NIS), by subtracting their national identity value to that of the information they have received:

$$NIS = \left|NI_{\mathrm{it}} - \mathrm{I_j}\right| \leq \mathrm{s}$$

where $|NI_{\mathrm{it}} - \mathrm{I_j}|$ corresponds to the absolute difference between agent *i* national identity and information *j* national identity value. *s* is the threshold parameter after (Deffuant et al. 2000, 2002, 2005) and it is of 0.5. Moreover, agents compute the national identity differences between Agent_i and each of its ties national identities $\mathrm{NI}_{j,t}$ to see the number of "friends" that would agree with the information if Agent_i was to share it out with the total number of ties $\left(\frac{\sum_{n=1}(X_{neighbours})}{2}\right)$.

$$GNIS = if \sum_{n=1}\left(\left|NI_i - NI_j\right| \leq \mathrm{s}\right) \geq \frac{\sum_{n=1}(X_{neighbours})}{2} = 1$$

$$= if \sum_{n=1}\left(\left|NI_i - NI_j\right| \leq \mathrm{s}\right) \leq \frac{\sum_{n=1}(X_{neighbours})}{2} = 0$$

where $|\mathrm{NI_{iX}} - \mathrm{I_X}|$ corresponds to the absolute difference between Agent_i national identity and $\mathrm{information}_j$ national identity value. We can speak of homophily, *GNIS* = 1, if the number of friends sharing the original agent's national identity is greater than seventy percent of the total number of ties Agent_i has. Alternatively, GNIS = 0, represents a social network with mixed national identities which increases the likelihood of sharing diverse information since there is no majority national identity.

4.2.2 National identity update

Similarly to the previous step, the agent calculates the similarity between the information received and their own national identities (NIS). The following equation formalises the national identity decisions (NID) which considers whether the information has been received from a tie,

SN =1, or from the media, SN= 0. This is significant because if the information was received from a tie, the weight of that tie, W_{ij}, is computed.

$$\begin{aligned} \text{NID} = \; & If\ SN = 1, \quad \left|\text{NIS} - W_{ij}\right| \geq NidC_i \\ = \; & If\ SN = 0, \quad NIS \geq NidC_i \end{aligned}$$

where NIS, same process as for the Sharing Rule comparing the agent's opinions to those of the information received. W_{ij} is the weight of the dyadic tie between *i* and *j* ($-1.0 < W_{ij} < 1.0$). If the tie is part of the ingroup, their social influence will be increased by 0.1 compared to the tie being part of the outgroup. $NidC_i$ is the agent's certainty about their opinions ($0 < NidC_i < 1.0$) to replace the bounded confidence threshold parameter of Deffuant et al., (2000, 2002).

$Agent_i$ update their national identity accordingly depending on its (dis)similarity with their own. If the national identity is sufficiently similar (a), their difference is below 0.5, then the opinion change will add that difference times a constant to the original opinion. If they are too dissimilar, (b) the negative different times a constant will be added to the original national identity:

$$\begin{aligned} &\text{(a)}\ NI_{it} = NI_{it} + u * |NI_{\text{it}} - \text{I}_\text{j}| \\ &\text{(b)}\ NI_{it} = NI_{it} - \text{u} * |NI_{\text{it}} - \text{I}_\text{j}| \end{aligned} \qquad \text{(from Salzarulo, 2006)}$$

4.2.3 Protesting process

The probability $CAD_{protest,i}$ of agent *i* to participate in protest at moment t is:

$$\begin{aligned} \text{CAD}_{\text{protest,i}} = & If\ \frac{\left(\text{Grie}_\text{i} + \text{Grie}_{\text{neigh}}\right)}{2} + \left(\text{P}_{\text{support}} * \text{h}\right) \geq \text{Costs}_\text{i} + \left(\text{P}_{\text{against}} * h\right) \\ & \Rightarrow \text{PState}_{\text{it}} = 1 \end{aligned}$$

Where $\mathrm{Grie}_{\mathrm{I}}$ represents the grievances perception $\mathrm{Agent}_{\mathrm{i}}$ has. $\mathrm{G}_{\mathrm{neigh}}$ represents $\mathrm{agent}_{\mathrm{i}}$ tie's grievance perceptions but only of those perceptions, social connections under the national identity similarity threshold ($|\mathrm{NI}_{\mathrm{i,t}} - \mathrm{NI}_{\mathrm{j,t}}| < 0.5|$), representing group identity. $\mathrm{P}_{\mathrm{support}}$ and $\mathrm{P}_{\mathrm{against}}$ represent the neighbourhood protest participation. Out of the total number of ties a given agent has how many are either protesting or silent. This value is then multiplied by a constant, *h*, representing the weight of critical mass theory.

If the above holds true, the agent will become a protester, $\mathrm{PState}_{\mathrm{it}}$ and influence their in-group ties to protest via social influence. In other words, those neighbours that fall under the NIS threshold will increase their grievances by a constant, *s*. Conversely, if the agent remains silent this will persuade others to remain silent and the agent's neighbours grievances will be reduced by the same constant, *s*.

4.3 Model procedure

Figure 4 represents the model procedure for each day where agents perform all four actions. The step begins with an agent chosen at random receives information from the media. From there the agent has to decide whether or not to share that information and whether or not to change their opinions based on that information. After that the agent will decide whether or not to protest.

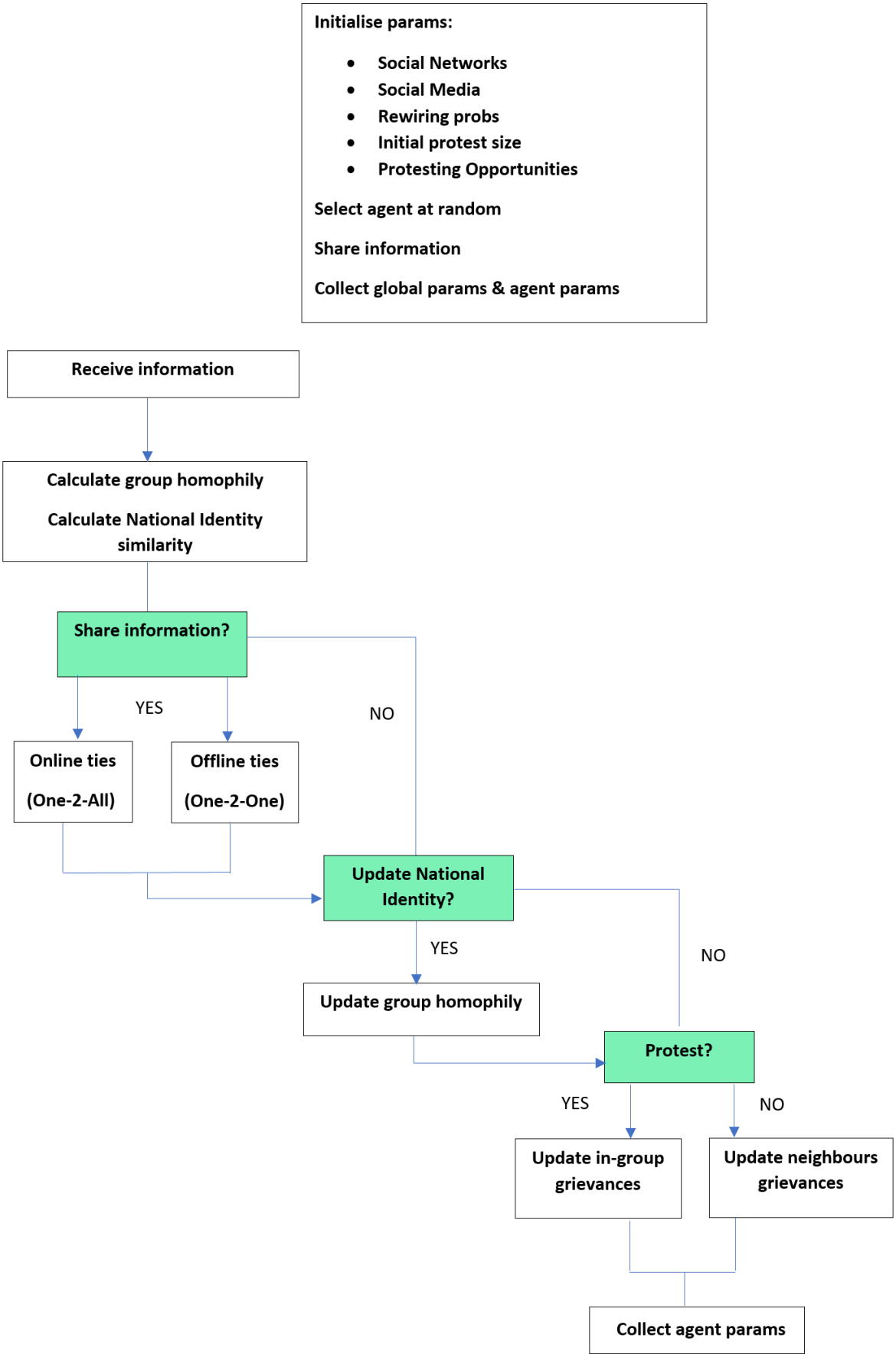

Figure 4: Model procedure for every step.

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