**Title**

**Abstract**

**To incorporate:**

Boutyline, A., & Willer, R. (2017). The social structure of political echo chambers: Variation in ideological homophily in online networks. *Political psychology*, *38*(3), 551-569.

**1. Introduction**

Twitter is a popular communication tool among politicians. Twitter is simple and easy to use and it allows politicians to directly communicate and engage with the population and pundits (e.g. Klinger and Svensson 2015; Spierings and Jacobs 2019; Spierings, Jacobs, and Linders 2019; Tromble 2018) Consequently, Members of Parliament (MPs) have debates, make friends, advertise accomplishments, share information, and form allegiances on Twitter. Being successful on Twitter, as indicated by having many followers, retweets or @-mentions, is considered part of MPs power base by media, party leaders, and selection committees (Jacobs and Spierings 2019) and is likely to have consequences for real-life politics in terms of who gets attention, which policy frames become dominant, and what position an MPs attains within the party hierarchy (Karlsen and Enjolras 2016; Spierings and Jacobs 2014; Waters, Tindall, and Morton 2010).

When looking at with whom politicians such as MPs actively connect and interact on Twitter, other politicians are strongly overrepresented. Although politicians naturally only make up a small part of the pool of possible Twitter ‘friends’, a study on Dutch MPs estimated that over 40 per cent of the accounts MPs follow are other politicians (Spierings et al. 2019). Communication and engagement on Twitter by MPs with other MPs may increase general Twitter visibility. Moreover, tweeting with MPs who represent groups one has no contact with offline might facilitate the formation of stronger offline networks and parliamentary collaboration between dissimilar colleagues. On the other hand, if twitter networks among MPs are divided across party lines or other important social dimensions such as sex, age and ethnicity, this could lead to information bubbles, political polarization and, in extremis, harm political functioning.

The current research on politicians’ use of social twitter mainly focuses on politicians’ vertical connections: how they create relations and engage with their electorate, or how they use Twitter contact with journalists to reach potential voters (Jungherr 2016; Kruikemeier 2014). Research into the Twitter networks among MPs is rare. [here Hsu and Park] Another noteworthy exception is the study of Del Valle and Bravo (2018) in which it is demonstrated that the twitter networks among Catalan parliamentarians are segregated along party and ideological lines. Consequently, Twitter would function as an ‘ideological echo chamber’ in which MPs are mostly exposed to MPs with consonant views, according to Del Valle and Bravo. However, they did not theorize or test other fault lines and it is unclear to what extent the Catalan results are generalizable beyond their regional Spanish case.

In this contribution, we will therefore investigate segregation in Twitter networks among parliamentarians in The Netherlands. With Twittter networks we refer to the multi-layered (or multiplex) directed network formed through following, @-mentioning and retweeting relations. Network segregation is understood as dense in-group relations and scarce out-group relations. Theoretically, we bring together the conceptual notion of digital architectures, or affordances, from the political communication literature (Bossetta 2018) and the literature on segregation dynamics in online social networks (Boutyline and Willer 2017; Hofstra et al. 2017; Lin and Lundquist 2013; Wimmer and Lewis 2010). We provide a more thorough understanding of MPs digital social networks, and particularly with respect to four issues of political segregation: (a) to what extent are the Twitter networks among MPs segregated?; (b) to what extent are the observed segregation patterns along party membership lines on Twitter a by-product of social homophily (i.e., the preferences to form ties with similar others)?; (c) to what extent do the segregation patterns within the three network layers formed by following, @-mentioning and retweeting relations reinforce each other?; and (d) to what extent do segregation patterns change over time?

More specifically, our empirical focus will be on how relations within the three layers of the Twitter network among the 150 Dutch MPs have evolved after the national elections of 2017. Where the Catalan case of Valle and Bravo (2018) is a most likely case to observe party cleavages in MPs’ twitter networks, because of the strong independence movement, the Dutch case could be seen as a least likely case to observe segregation in twitter networks, because of the multiparty system with a very large number of effective parties. After the 2017 elections, 13 parties were presented in Parliament by 150 MPs and the effective number of parties above 8 (Casal Bértoa 2021). In parliament, political opponents need to collaborate, not only to form and support a government, but also to find majorities for specific proposals and to become an effective party in either coalition or opposition. In such a setting, we might expect less clear party and ideological division lines running across MPs’ Twitter networks, whereas MPs from different parties might form networks around for instance gender or minority status. In other words, if ideological and party divides are still found in the Netherlands, this is a strong confirmation of the prior findings by del Valle and Bravo (2018). We thus present a replication in a different site, which is relevant in itself, but at the same time, we also expand on previous work in several important ways.

Theoretically, we acknowledge that (1) segregation may manifest itself not only along party membership lines but also along traditional social dimensions; (2) that Twitter consists of different network layers and segregation may manifest itself differently in each layer; (3) that the degree of segregation may change over time. We will discuss each step forward in more detail in the ‘Theoretical background section’ below. Methodologically, we take advantage of unique longitudinal complete network data on Twitter relations among Dutch MPs collected in April 2017, June 2017 and September 2017. We will first visually inspect these networks before giving a description of the observed degree of segregation by different formal network segregation measures. We will complement this descriptive part with a Stochastic Actor-Orientated Modelling approach as implemented in RSiena (Ripley et al. 2021; Snijders, Van de Bunt, and Steglich 2010). RSiena allows us to assess (political) segregation among MPs while controlling for structural network effects and a wide array of MP characteristics (at the ego, alter and dyad-level) that may influence whether relations between MPs are present. Our data and modelling strategy is discussed in more detail in section ‘Data and Methods’.

**2. Theoretical background**

***Multi-dimensionality: Segregation in Twitter along political and social dimensions.***

Whereas previous studies focused on cleavages along political dimensions alone (Del Valle and Bravo 2018; Hsu and Park 2012), we will also investigate socio-demographic segregation within MPs’ Twitter networks along major axis of representation: sex, age and ethnicity (Celis and Mügge 2018). This focus aligns with and builds on crucial insights from social network studies. Particularly, we distinguish between structure-based and choice-based mechanisms leading to network segregation below.

It has been a well-established finding that social interactions are more likely between people who are similar (McPherson, Smith-Lovin, and Cook 2001). The observed degree of network homogeneity is to a large extent the result of the opportunity structure, i.e., the availability of contact partners within and outside one’s group. Moreover, initial levels of network segregation may be amplified by common structural network processes such as reciprocity (i.e., “If you scratch my back, I will scratch yours.”) and transitivity (i.e., “Friends of friends become friends.”). Over and above such structurally-induced network homogeneity, people commonly have preferences to interact with similar others. These inbreeding homophily preferences surface in the choices that individuals make regarding whom to form ties with. Inbreeding homophily – aka choice homophily – contributes to segregation as it results in ties being more likely within specific groups and less likely between different groups than could be expected on opportunity structures and structural network processes alone.[[1]](#endnote-1)

The above refers to general mechanisms that can be translated to different domains of social interaction and settings. Network homogeneity is observed across a wide array of social dimensions and for different type of social relations but studies on segregation in extended online networks have remained rare. One may intuitively expect that the degree of segregation would be less pronounced in online than offline networks and in extended versus core networks, because online there are less structural constraints and because the (emotional) risk involved in forming ‘wrong’ relations in extended networks of weak ties would be lower than in core networks formed by strong ties. That being said, corroborative empirical evidence for this idea has been meagre at best (Hofstra et al. 2017). The online Twitter networks of MPs in parliament move beyond the core network but MPs will be exposed to each other in parliament as well. It therefore remains an open question whether real-life social cleavages based on sex-, age- and ethnicity are mitigated by Twitter or that Twitter reifies these social divides in parliament.

As in other countries, Dutch political parties differ in their socio-demographic composition (Table 1). For instance, after the 2017 elections, women were underrepresented in parliament (54 MPs, 36%) and in most factions, women hold a numerical minority position. The exceptions are found among some within the political left: Greens (8 MPs, 57%); Social Democrats (5MPs, 56%); and Party for the Animals (3MPs, 60%). The mean age of MPs in parliament does slightly deviate downwards from the mean age in the general Dutch electorate (45 versus 50) but there are striking differences across parties. The MPs of the 50Plus party, a party specifically targeting the elderly, have a mean age of 65 year. The mean age of MPs of the radical left party SP is just over 38. Lastly, in The Netherlands, the share of MPs with a visible ethnic-minority background reflects the group size within the electorate fairly well (Van der Zwan, Lubbers, and Eisinga 2019), but zooming in we see that some specific groups are overrepresented, such as Moroccan-background Dutch citizens, while other are underrepresented, like Suriname-background Dutch citizens. Moreover, we observe marked differences across parties. In the 2017 election, a new ethnic-minority party DENK entered the arena, focusing in their campaign on racism and discrimination in Dutch society, and they won three seats in parliament. All three MPs have an ethnic-minoirty background. At the other end of the ideological spectrum, the populist radical right Freedom Party of Geert Wilders also has 1 MP (5%) who has a visibly-noticable ethnic-minority background.

Considering these differences in social composition across parties, political segregation in Twitter networks could be the result of selective interaction along party lines, as well as of social inbreeding homophily, selecting Twitter partners based on attributes other than party membership. In this contribution, we will assess exactly that: the extent of political segregation, the degree of sex, age and ethnicity-based network segregation in Twitter networks, and the extent to which political segregation in Twitter networks along party-membership among Dutch MPs is a by-product of social inbreeding homophily (c.f. Kalmijn 1998; Smith, Maas, and Van Tubergen 2014).

**<<< Table 1. Socio-demographic characteristics of Dutch parliament and per political party >>>**

***Multiplexity: segregation in different layers of the Twitter network***

Up until here we discussed network formation in general terms. However, networks come in many different types and sizes. Even when we focus on a single social media platform, different layers of social networks are created due to different types of interaction being part of the platform’s affordances of digital architecture (Bossetta 2018). Three of the most prominent layers of interaction on Twitter include follow relations, retweets and @-mentions. Discussing the nature of these forms of interaction is our next theoretical building block.

On Twitter, one can follow another account in a non-reciprocal way. Once a connection is made, the tweets of the followee will appear in the timeline of the follower. Following an account could thus indicate that a follower finds the content posted by the followee interesting, regardless of whether one agrees or disagrees with the content of the followee. Forming (reciprocal) following relations can also be used strategically to boost the prominence of an account, because this will increase the likelihood that one’s own tweets are shown in the timelines of others with whom no following relation is formed. In this respect, it should be noted though, that although political parties want their politicians to have and show large numbers of followers, hardly any party in the Netherlands seems to actively stimulate their MPs to follow each other on Twitter (Jacobs and Spierings 2016).

Twitter also allows users to basically copy a post of another user and push it to their own followers via the retweet function. Retweeting a message indicates that the original tweet is deemed an interesting enough intervention in the public debate to pass it on to one’s own followers. Although politicians tend to explicitly claim that a retweet is not necessarily an endorsement (Boyd, Golder, and Lotan 2010; Klinger and Svensson 2015; Metaxas et al. 2015), particularly among politicians, retweeting a message of another politician one disagrees with is relatively unlikely, because the retweet function is mainly a passing on of content. The exception here is retweeting a post by ‘quoting’ it (as Twitter calls this) and adding one’s own take on the issue. This function can be used to show what one disagrees with. While this is not uncommon, retweets are of the three relationship types the one most likely to signal positive affect.

In contrast, the @-mention functionality of twitter is of the three most likely to be used by politicians for debating with opponents and to signal negative affect. There are two ways in which one could @-mention others. First, a user can write a post and invite others to be aware of, look at, or respond to that post by including the person in the message using the @-mention. If one does so, the @-mentioned account gets a notification, strongly increasing the likelihood that the tweet is noticed by the @-mentioned person. Second, below each tweet, Twitter puts a small speech bubble icon via which users can directly, but publicly, reply to a message. Using this function automatically leads to including the poster of the original message to be @-mentioned in the reply. This way, Twitter facilitates interaction among users. Overall, the @-mention is thus used for ‘calling upon a person’, holding conversations, and debating (Spierings and Jacobs 2019).

Given their different functions, and the presumed different emotional valence attached to the different type of ties, MPs may hold different structural positions in each network-layer and the network structures present in each layer of Twittersphere – most importantly the degree of segregation – do not necessarily need to be similar (Del Valle and Bravo 2018). So far, it has remained unclear how the different Twitter network types co-evolve. Does debating with opponents makes friendships (i.e., following relations) with opponents more likely, or are MPs more likely to ignore their opponents and prefer to engage in debates with MPs they already follow? In the present contribution we take this so-called multiplexity of twittersphere into account. We will assess the extent to which the degree of segregation differs across layers, and how segregation in one layer of the twitter network impacts segregation in another layer, i.e., how the different elements of the digital architecture are interrelated and may reinforce each other.

***Multiple time points: development of segregation in Twitter over time.***

Finally, we also expand on previous work by investigating the over-time (co-)development of the three Twitter networks. More concretely, we will investigate how the Twitter networks among Dutch MPs have evolved between May 2017 and October 2017. In May 2017 a new, 13-party, parliament was installed following the elections of March 2017. In October 2017, a new government was formed after more than 200 days of fierce negotiations among different potential coalition partners.

Politicians of the same party who have been elected as MP are likely to have worked together before or during the campaigns leading up to the election. Their shared social contexts will undoubtedly have led to (structurally-induced) homogeneity in their offline relations (Feld 1981), and could have translated into their online Twitter relations. Following this line of reasoning and the lead of previous research demonstrating the ubiquitous presence of network segregation (Colleoni, Rozza, and Arvidsson 2014; Del Valle and Bravo 2018; McPherson et al. 2001), we thus expect to see at least some degree of segregation in the Twitter networks based on party-membership shortly after the time when parliament is established.

The degree of segregation is, however, unlikely to be stable. Common structural network dynamics like reciprocity and transitive closure may act as catalyzer and may contribute to the further over-representation of intra-party relations, thereby increasing the degree of segregation. On the other hand, the presumed initial segregation in twittershpere may be overcome merely because offline contact and exposure to dissimilar MPs in the house increases. Such a process was argued for among the public’s political discussion network by (Brundidge 2010), who found evidence that through inadvertent exposure, the Internet increased the heterogeneity of political discussion networks, and thus people’s exposure to political difference. Contrasting the often alluded to echo chamber effect, interview-based studies have shown that Twitter is used by politicians as a political instrument to be aware of what opponents think and say (Jacobs and Spierings 2016), which actually facilitates cross-ideological contacts. Our unique time window enables us to assess the development of segregation in Twittersphere over time, showing how it increases or decreases, while taking into account structural network dynamics.

***Expectations***

Given the rationale outlined above and based on previous research on segregation in Twitter networks (Colleoni et al. 2014; Del Valle and Bravo 2018; Hsu and Park 2012), we expect to observe at least some degree of segregation along the party dimension in all three Twitter networks of Dutch MPs, and thus that MPs are more likely to interact on Twitter with same party MPs relative to MPs from different parties, even after we take structurally induced network segregation resulting from differences in opportunity structures and structural network dynamics into account (Hypothesis 1).

Since political parties have different social compositions and inbreeding homophily has been observed previously across a wide array of social dimensions, among which sex, age and ethnicity, for different type of offline and online networks, we therefore expect to observe social divisions on twitter along these social dimensions as well (Hypothesis 2a), and that political segregation in Twittersphere will in part be a by-product of inbreeding homophily in these social dimensions (Hypothesis 2b).

We expect that segregation will be most pronounced in the retweet layer of the twitter network, as this type of relation is of the three most likely to be formed between MPs who evaluate each other positively (Hypothesis 3a). In a similar vein, the @mention relation will, in contrast, be formed more between political foes as they debate each other on twitter. Hence, of the three layers, we expect to observe the lowest degree of political segregation in the @mention layer (Hypothesis 3b). Regarding the third layer, one may follow MPs on Twitter because of positive reasons, for example MPs may like the follower and/or want to increase the Twitter visibility of the follower, or for negative reasons when MPs want to be informed what political foe tweets. Hence, we expect the degree of political segregation in this layer will fall between the retweet and @mention layer (Hypothesis 3c).

From previous research, we know that (physical) proximity and exposure to others is a very important determinant for tie formation and maintenance (Rivera, Soderstrom, and Uzzi 2010). Once you follow someone on twitter or are followed by someone, the tweets of this followee/follower become more visible to you. Hence, we expect that the digital proximity that results from a follow relation on twitter will increase opportunities for both MPs to retweet each other’s tweets or to react on tweets via @mentions. Consequently, we expect follow relations to increase retweet and @mention relations and thus that the degree of segregation in the retweet and @mention layer is in part the result of the degree of segregation in the follower layer (Hypothesis 4a and 4b). Similarly, when an MP retweets another MPs tweet or @mentions them, this may be an incentive for the second MP to become closer to the first MP and to start following this MP. Thus, we expect that segregation in the friendship network will also be in part the result of segregation in the retweet and @mention network (Hypothesis 4c and 4d).

Finally, we could expect that initial levels of segregation may deepen, because of inbreeding homophily and structural network dynamics, in line with the idea of the development of political echo chambers. On the other hand, networks may become more integrated over time because of the (offline) meeting opportunities with dissimilar MPs in the House. MPs may also form new (strategic) follower relations with dissimilar MPs, because they want to be informed on the Twitter content of these dissimilar MPs. Similarly, MPs may enter @mention discussions with political opponents on twitter, either steered by genuine political motives or to strategically increase Twitter visibility. From a theoretical perspective of network dynamics and digital architectures, both mechanisms are likely to occur and we cannot deduce a priori expectation on whether deepening or easing segregation will dominate. Therefore, we only formulate a research question on this to explore the development of segregation in Twitter over time: To what extent do the different forms of segregation in the different layers of Twitter networks among MPs deepen or ease over time? (Research question 1)

**3. Data and methods**

The Netherlands is a Twitter frontrunner, with a high adoption rate among MPs (>85% since 2012). Before the elections of 15 March 2017, we searched for relevant twitter handles for all persons on election lists. Of the 150 politicians who eventually entered parliament we have 147 twitter handles; the other three did not have a known Twitter account (Tony van Dijck (PVV), Sietse Fitsma (PVV) and Albert van den Bosch (VVD)). We used the Twitter REST API to map follower and retweet relations and the Twitter SEARCH API to map @-mention relations at three time-points (April 2017, June 2017 and September 2017; two time-periods of 85 days).

The *sex* of MPs is taken from the election lists, which provides this for all candidates. The *age* (or more precisely birth year) of the MPs was collected via the official website of the House of Parliament ([www.tweedekamer.nl](http://www.tweedekamer.nl)). For our descriptive analyses we constructed a dummy variable indicating whether the age difference between two MPs was less than 6 years. We considered MPs as having a *visible ethnic-minority background* using a common contextual definition and procedure in the literature on representation: name and photo recognition or being well-known as such (Bird 2005; Bloemraad and Schönwälder 2013). This approaches avoids issues of how to define ‘non-Western migration background’, which in the Dutch case for instance excludes MPs with an Indonesian roots even though they are likely to identify and be treated as ethnic minority in terms of segregation. At the same time, we do include second generation migrants who do not identify as such. For instance, prominent MP Vera Bergkamp has a Moroccan father but this is not wellknown and she hardly ever brings it up or makes it part of her politics. Given her appearance, it is also highly unlikely that she is treated as such in the streets. In terms of measurement, we used the codes of MP as underlying prior work on the Netherlands (Jacobs and Spierings 2019; Spierings et al. 2019). The MPs who where not listed in previous elections (which those prior studies made use of), we coded ourselves, using the same criterions. Consequently, we consider 16 MPs (11%) as belonging to a ‘visible ethnic-minority’.

In our multivariate explanatory models, we take into account several control variables at the ego, alter and dyad-level: party-leadership, position on the election list, (difference in) incumbency status of MPs, where we defined incumbency here as having been Member of Parliament before the 2017 election, and physical proximity within parliament based on the seating positions of MPs in April 2017 (collected via the android app [name?] developed by PRODEMOS (<https://prodemos.nl/>)). Descriptive statistics of our main concepts are summarized at the party-level in Table 1. The dataset on all 150 MPs is accessible via our github repository and replication website (\*\*\*).

***Analytical strategy***

We will start with a visual inspection of the directed and reciprocated ties present in the three network layers. We then move on to a description of the extent of segregation by formal statistics. There are many ways to measure segregation in social networks (Bojanowski and Corten 2014). Staying close to our definition of segregation, we start with comparing intragroup and intergroup densities. Network density is easy to interpret, but it does not take into account relative groups sizes nor that MPs differ in activity (number of outdegrees) and popularity (number of indegrees), while differences in group sizes and unequal degree distributions alone may already cause structurally induced differences in inter- and intra-group densities. A measure of segregation that ‘controls for’ relative group sizes and degree distributions is Coleman’s Homophily Index. In this measure a value of 0 would indicate that the observed number of within-group ties is the same as would be expected under random choice by MPs. A value of 1 would indicate maximum and a value of -1 indicates the unlikely case that MPs maximally avoid within group relations. [finally]

If our descriptive results are stable across different – but all informative – measures of segregation, we will be able to view results as reliable.

Although the descriptive part will inform us about the actual segregation in the network layers, they do not provide explanations for the found segregation. For that we need take into account how Twitter relations are formed and broken, how forming and breaking connections may depend on structural network effects (i.e., how the network structure at time T influences the network structure at time T + 1) and on ego, alter and dyad covariate effects (i.e., the extent to which ego, alter and dyad characteristics influence the likelihood that a tie is present). Our data refers to three snap-shots of complete networks on a fixed node set (the MPs). For the statistical analysis of these network data we turn to the SAOM (Stochastic Actor Oriented Model) as implemented in SIENA (Simulation Investigation for Empirical Network Analysis) (Ripley et al. 2021), which we will estimate within the software package R (R Core Team 2021).

With RSiena, tie changes are modelled as resulting from actions by actors (or agents). An important assumption of the implemented SAOM is that of the so-called *ministep.* Only one actor (or agent) per time is allowed to make a tie change, and this actor can change only one tie at a time.[[2]](#endnote-2) The decision on tie change, including the option of no change, is based on how the actor that is being allowed to change evaluates the current and possible future network structures in its direct vicinity. How these networks are evaluated is determined by the so-called evaluation function:

finet(x) = Σkβknetsiknet(x)

Thus, finet(x) is the evaluation function. And it maps a value to the attractiveness of the network, x. βknet refers to the estimated parameters of the model and these parameters of the evaluation function are what we are interested in. For each network effect k, siknet, (also called a network statistic) we will obtain a separate parameter estimate indicating the strength of the network effect. Each agent evaluates the attractiveness of its local network environment. This is why si has a subscript i. Based on the mathematical definitions of the included network effects siknet, agent *i* will determine the attractiveness of the possible networks that may result from a ministep. Agent i is most likely to take the ministep that will result in the network with the highest attractiveness value, thus higher values of the evaluation function indicate the preferred direction of change. Suppose that actor *i* who is allowed to make a tie change can choose between tree possible future network states: *xa*, *xb* and*xc*. The probability that the tie change that will result in *xa* (from all possible networks *X)* is chosen is then given by:

The interpretation of the parameters of the evaluation function resembles the interpretation of a logistic regression: exp(βknet) is the ratio of the probabilities to observe network *xa* versus *xb*, under the ceteris paribus condition that the only difference between these networks is that siknet(*xa*) - siknet(*xb*) = 1.[[3]](#endnote-3)

Following the Rsiena manual (Ripley et al. 2021) , we started with a preliminary model for the three dependent network-variables (i.e., follower, retweeting, @mention) in which we included (uniplex) structural network effects only (next to time-period specific rate functions): *out-degree* and *reciprocity* effects, *in-degree popularity* (square root version), *out-degree activity* (square root version), *out-degree popularity* (square root version) and *transitive triplets*. We supplemented this model with the *shared popularity* effect.[[4]](#endnote-4) The out-degree effect can be seen as a constant, the likelihood to observe a tie. The reciprocity effect assesses the extent to which forming a reciprocated tie is more likely than a non-reciprocated tie. In-degree popularity and out-degree activity take into account the dispersion in degrees, that is, that MPs who receive/send many ties at time T also receive/send many ties at time T + 1. The out-degree popularity effect models the covariance between indegrees and out-degrees. With the transitive triplets effect we test network closure and its interpretation can best be explained by the expression “friends of friends are my friends”. With the shared shared popularity effect we aim to capture complex contagion processes, whereby MPs are more likely to form a new (follower, @-mentoin, retweet) relation which they already observe among the MPs they are already connected to (c.f., Harrigan, Achananuparp, and Lim 2012). For the mathematical definition of each included network statistic we refer to chapter 12 of the RSiena manual (Ripley et al. 2021).

With this structural-effects-only model we reached an acceptable fit (with an overall maximum convergence ratio of .16; see github replication website here). We subsequently included controls for MPs activity and MPs popularity: *political party*, *party-leadership*, *position on election ballot*, and *incumbency status*. The dyadic control covariates were: MPs *similarity in incumbency status* and the *seating distance* between MPs. Moreover, this model also includes our main variable of interest, namely the dyadic covariate MPs *similarity in party membership* with which we intend to test hypotheses 1. Positive values of the corresponding parameter estimate will indicate that MPs are more likely to form ties with co-party members than with MPs from a different political party. Parameters estimates with a *t*-value smaller than one were subsequently dropped to obtain an acceptable fit of the model.

To assess the degree of segregation along sex, age, and ethnic lines and to assess the extent to which segregation along party division lines is a by-product of online social inbreeding homophily (Hypotheses 2a and 2b) we included in Model 2 the relevant dyadic covariates (*same sex*, *age difference*, *same visible minority status*). We also included the corresponding covariates at the ego and alter level (*sex*, *age*, *visible minority*) in this model, to make sure our segregation estimates are not biased by ego and alter effects. We subsequently dropped the respective estimates at the ego/alter-level with a *t*-value smaller than one to obtain an adequate model fit. With this model, we will compare the remaining degree of segregation along the party dimension across the three dependent variables to test hypothesis 3.

In our next model, Model 3, we added the following structural multiplex effects between on the one hand the follow-layer and on the other hand the retweet and @-mention layer: *crprod* and *crprodRecip*. Cross-network effects between the retweet and @mention layer were thus not included. With the crprod effect we assess the likelihood for an MP who has a specific relation with another MP (e.g., follower) to also ‘send’ a different relation to this MP (e.g., retweet or @-mention relation). The crprodRecip effect captures the effect that if an MP has a specific relation with another MP (e.g., follower) this MP will ‘receive’ a different relation from this MP (e.g., retweet or @-mention). Once again, we dropped estimates with a *t*-value smaller than one (now also including estimates referring to social inbreeding homophily). With the resulting model we investigate whether segregation in one layer of Twittersphere causes segregation in another layer (hypothesis 4).

With the score test implemented in the Rsiena ‘sienaTimeTest’ function we assessed whether there was time heterogeneity present in our parameter values referring to segregation across party lines in Model 3. The parameters of interest of the resulting Models 1, 2 and 3 are summarized in Table 4. The full models can be found in Appendix 1 and on our replication website.

We refer the interested reader who would like to replicate all reported findings in our manuscript, or who wants to assess how robust our findings are for alternative modelling strategies, to the replication github website, accompanying this paper (\*\*\*).

**<<<Figures 1-3>>>**

**4. Results**

***Observed segregation***

The networks that existed in April 2017 among the Dutch MPs are summarized in Figures 1-3. It becomes apparent immediately that the density – the number of observed ties divided by all possible ties – is much higher in the follower network (0.25, Table 2) than in the @mention (0.05, Table 2) or retweet (0.05, Table 2) layer. This means that MPs are more likely to be connected as follower-followee than that they retweet or @mention each other. The nodes in the directed networks of Figure 1-3 are proportional to their outdegree (the number of other MPs they follow, retweet or @mention). In each layer of the Twitter network, we observe quite some variation across MPs in outdegree to which we already alluded to in the introduction. It are not necessarily the same MPs who have a relative high outdegree in each network layer. For example, Pieter Heerma (Christian Democrats) follows most other MPs, Peter Kwint, (Socialist Party) @mentions most other MPs, and Dilan Yesilgöz-Zegerius (Conservative Liberals) retweets other MPs’ posts most. That MPs hold different network positions in each layer is also evidenced by the weak Spearman’s rank order correlation between follower outdegrees and @mention outdegree (.39) and between the @mention outdegree and retweet outdegree (.53). These observations underline the importance to investigate the degree of segregation and underlying mechanism in the three interdependent network layers.

While Figure 1-3 provide insight in the layers of the Twitter network, they do not (easily) show whether twitter division lines run across the different political parties in the House of Parliament. The graphical summary of reciprocated relations in the Twittersphere of MPs (Figure 4-6) are more informative in that respect. It seems that, as expected, especially (reciprocated) @mention relations go across party boundaries. At the same time, especially (reciprocated) retweet relations predominantly exist between MPs of the same party.

***Segregation indices***

*Segregation along party lines*

We observe that Twitter relations with MPs of the same political party are substantially more common than with MPs of other parties (e.g., 0.71 over 0.19 for follower networks at wave 1; Table xxx ). This holds true for all network layers within Twitter and all three time points. Also based on our other two segregation measures we observe segregation along party lines: … and … . .

*Segregation along social dimensions*

Considering the different socio-demographic axis of segregation, Twitter relations with same-sex MPs are not substantially more common than different-sex relations. Moreover, MPs who have a similar age (i.e., less than a 6-year difference) are more likely to have twitter ties than MPs with a dissimilar age. Lastly, follower relations on Twitter between MPs with the same ethnic background are more common (same ethnicity > different ethnicity).

According to the Coleman’s homophily index, we not only observe segregation along party lines but also along sex and ethnic division lines, although not very substantially. The resulting segregation patterns based on Newman’s assortativity coefficient are quite consistent with our previously described results. In general, we observe segregation along all social dimensions and age-based segregation seems to be stronger than segregation along sex or ethnicity.

*Comparison of segregation patterns along the different Twitter layers*

According to both Coleman’s homophily index and Newman’s assortativity coefficient, we would conclude that segregation patterns are most pronounced within the retweet network. This finding supports our conclusion based on a visual inspection of the Twitter networks above (Figure 4-6) and is in line with the architectural reasoning that retweets are generally endorsements of the original tweet.

*Development of segregation in Twitter over*

The density of the friendship network increases over time, which is not a real surprise because unfriending someone on Twitter is a rare event and we focus on a relatively small group of politicians with seats in parliament to which several new members are introduced through the elections. On the other hand, the density of the retweet and @-mentioning network decreased over time. This may indicate that after the campaigning period of the elections and government formation, politicians feel less of an urge to be visible for their electorate via Twitter and take it a notch back after the intensive and energy-consuming events elections are. However, regarding the segregation patterns, we observe no discernible trends in our time-window.

**<<<Table 2>>>**

**<<<Table 3>>>**

***RSiena results***

*Structural and covariate effects*

Before we will discuss our main results, we briefly describe the observed structural effects and the estimated covariate effects. In all three network layers we observe positive and significant reciprocity effects: a reciprocated tie is preferred over a non-reciprocated tie. Reciprocity effects are strongest in the @mention layer, likely reflecting that MPs hold small back-and-forth conversations or discussions via Twitter. Our significant indegree popularity and out-degree activity estimates demonstrate the significant dispersion of out-degrees (i.e., activity) and in-degrees (i.e., popularity). Interestingly, more active MPs are significantly less popular, as indicated by the negative outdegree-popularity parameters. This could indicate that less important MPs try to use Twitter to gain prominence and that some more prominent politicians do not need Twitter or have less time to invest in it (see Jacobs & Spierings, 2016; Jungherr, 2014). All networks show transitive closure (e.g., MPs are likely to follow MPs who are followed by MPs already being followed). The shared popularity effect was negative in all three layers but only reached significance in the retweet layer. In other words, different MPs have their unique ‘fan base’ of MPs which retweets their tweets. This finding is in line with the theory that social contagion is lower within a community because of the inherent redundancy and lack of novelty of messages within a community but contradicts the idea that tweets spread via complex social contagion (Harrigan et al. 2012).

Incumbent MPs follow less other MPs and are followed by fewer MPs. Notably, follow relations are more likely within the subgroups of incumbent and non-incumbent MPs than between these subgroups, probably because of the different shared (political) history and meeting opportunities during the previous parliament. Incumbent MPs also retweet less and are retweetet less often. MPs with a better ballot position follow fewer other MPs but are retweetet and @mentioned more, possibly indicating that MPs with a less favourable position on the ballot are less likely to hold and communicate important viewpoints on core political issues, according to other MPs. Party leaders initiate significantly less discussions on Twitter than non-party leaders as indicated by the corresponding negative and significant estimated ego covariate effect within the @mention layer. Party membership does not have a substantial impact on twitter relations although MPs of the Greens are @mentioned less often than others and tweets of MPs of the liberal democrats (D66) and the Freedom Party (PVV) are significantly less often retweeted.

Acknowledging that (real-life) contact opportunities may translate into contact in online twittersphere, we wanted to take the physical structure of parliament into account. Therefore, we included a measure of the distance between the seats of MPs as a dyadic covariate in our models. These 150 seats are allocated to the parties after the elections by the presidium based on party size and mimics to some extent the classical, economic left/right political dimension: the socialist party (SP) have seats on the left and the Freedom Party (PVV) have seats on the right in the house (see also Figures 1-6). Per party, party leadership determines which MPs sit on which of the allocated seats, with the party leader generally sitting on the first row. Our results indicate that seating position influences Twitter relations among MPs: the further MPs sit from one another (already accounting for list position and party affiliation), the less likely they are to follow and retweet each other. This likely reflects the impact of geographical distance, as expected, but we cannot rule out the influence of ideological distance.

*Political segregation*

Turning to our variable of interest, the ‘same party’ dyadic covariate, we find positive and significant estimates in all three layers of the Twitter network. Thus, even if we take into account structural network effects, factors that impact MPs’ activity and popularity, and the (physical and ideological) proximity between MPs within parliament, we still observe that MPs are more likely to form relations on Twitter with MPs of their own party than with MPs of different political parties. This finding is in line with our previous (descriptive) observations, and we thus clearly find corroborative evidence for Hypothesis 1.

More specifically, we expected to see party-based segregation most clearly in the retweet-layer and that the degree of political segregation would be lowest in the @mention layer, the follower-layer being in-between (Hypothesis 3a, 3b, and 3c respectively). This expected order of political segregation can indeed be observed but segregation in the retweet layer is not *significantly* higher than in the follow layer and segregation in the follow layer is not *significantly* stronger than in the @metnion layer*.* That being said, segregation in the retweet layer is clearly and significantly more pronounced than in the @mention layer: the difference is .466 with *s.e.* = .104 and *t*-ratio *t* = 4.446, *p* < 0. 001. Hence, overall, we find convincing corroborative evidence for the expected ordering of hypothesis 3.

*Socio-demographic segregation and it’s political by-product*

In Model 2 we assessed social inbreeding homophily. In the friendship layer, there is a tendency among MPs to befriend colleagues with the same sex. Surprisingly, and not in line with hypothesis 2a, the larger the age difference between MPs, the more likely it is that MPs follow each other. Also in contradiction to hypothesis 2a, MPs with a different visible ethnic minority status follow each other more often. In the @mention layer, we do not observe any social inbreeding homophily. The picture is once again different in the retweet-layer. Tweets are more likely retweeted by an MP of the same sex, supporting hypothesis 2a, but we do not observe homophily based on visible minority status or age in the retweet layer. In contrast to our descriptive findings, in our multivariate models, we only find weak evidence for social inbreeding homophily, only for sex based homophily and only within the follow and retweet layer hence we reject hypothesis 2a.

To be clear, the sex, age and ethnic background of MPs do impact twitter relations. Female MPs are more likely to be followed than male MPs and retweet tweets more often. Older MPs follow fewer other MPs, are followed less often themselves, and tweets of older MPs are retweeted less often. MPs with a visible ethnic minority status are more likely to retweet. But, to hammer the point home, there are no clear and consistent social division lines running through twittersphere in parliament. And with no pronounced social inbreeding homophily present, it is not surprising that our estimates referring to segregation along the party division lines are hardly affected. Party based segregation is not a by-product of social inbreeding homophily and we therefore refute hypothesis 2b.

*Segregation crossing network-layers*

We observe party-based segregation in all three layers of the Twitter network, which makes testing the idea that segregation in the follower network *causes* segregation in the @mention and retweet network and vice versa relevant. In Model 3 (Table 3) we therefore include crosprod and recipcross effects to our model. Our results reflect the digital architecture of Twitter. MPs are more likely to retweet and @mention tweets of MPs who they follow and – to a lesser extent – of MPs by whom they are followed. @mentioning an MP has a relatively strong impact on the chance to be retweeted by this MP but also on the chance to retweet the tweets of the this same MP, possibly indicating that twitter discussions also cross network layers. Retweeting has a similar impact on @mentioning albeit somewhat weaker. After taking these cross-network effects into account the positive same-party effect for the @mention network reduced substantially (from .922 in Model 2 to .407 in Model 3; …%) and somewhat for the retweet network (from 1.388 in Model 2 to 1.106 in Model 3; %). We therefore conclude that *because* MPs tend to follow MPs from their own party, Twitter discussions (@mentions) predominantly take place within party boundaries and information flows (i.e. retweets) across parties may be hampered.

*Over time*

…. Missing? … of is descriptive genoeg daarvoor? Dan dat ergens aangeven en onze RQ1 expliciet beantwoorden waar we over time results bespreken..

**5. Conclusion**

A positive interpretation would be that the @mention layer has a clear political function and here social division lines are less important than the political content of the tweets.

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1. Influence processes whereby connected individuals become more a like to each other over time are the major third mechanism that could lead to network homogeneity (next to structurally-induced network homogeneity and inbreeding homophily). Although it is possible that MPs change party memberships over time this is a relatively rare event. Similarly, MPs will not change their sex, age and ethnicity due to influence processes. Therefore, influence dynamics are not discussed in this contribution. [↑](#endnote-ref-1)
2. How often agents are allowed to make a change and which agent is allowed to change is determined by the rate-function but this is normally not the focus of interest. [↑](#endnote-ref-2)
3. Since: [↑](#endnote-ref-3)
4. [↑](#endnote-ref-4)