GENDER, RANK, AND SOCIAL NETWORKS ON AN ENTERPRISE SOCIAL MEDIA PLATFORM

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ABSTRACT

In this paper, we harness server-side data—540,000 messages generated by 2085 users on TamTamy, an Enterprise Social Media (ESM) platform—to examine how gender and rank shaped "homophily" (the tendency to connect with similar others) and centrality in an ESM network. Drawing on the logic of "distinctiveness theory," which argues that the numeric rarity of a category in a given setting promotes the use of that category as a basis for connecting with others, we hypothesized and found: (a) the tendency to connect with same-gender others was stronger among women than among men; (b) the tendency to connect with same-rank others was stronger among high-ranking employees than among low-ranking employees; (c) for high-ranking men, rank was more important than gender as a basis for connecting with others; and (d) for low-ranking women, gender was more important than rank as a basis for connecting with others. We also found that whereas higher ranking individuals were more likely to be in central (bridging) positions in the overall network, gender was unrelated to network centrality. Our study suggests that the affordances of ESM for open and distributed communications notwithstanding, the social networks that emerge on ESM platforms may reinforce social stratification on some dimensions while diminishing it on others.

Keywords: enterprise social media; social networks; gender; rank; homophily.

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PLATFORM

Individuals in organizations use their social networks for work accomplishment and support. Because the content and structure of these workplace social networks can have important implications for both individual and organizational success (e.g., Kilduff & Brass, 2010), substantial research has sought to understand the factors that shape these networks. A prominent line of work has focused on network "homophily," a sociological term reflecting the general preference for interaction with similar others (Lazarsfeld & Merton, 1954; McPherson, Smith-Lovin, & Cook, 2001). In the workplace, the tendency towards homophily is manifested in a bias towards building informal ties with individuals of the same gender and hierarchical rank (Brass, 1985; Ibarra, 1992; Lincoln & Miller, 1979). Similarity in terms of these salient individual attributes signals similarity in underlying attitudes and preferences and is therefore a common basis for spontaneous interpersonal attraction (Byrne, 1971). Indeed, even when people are given the explicit opportunity to connect with diverse others, they tend to find themselves connecting with similar others instead (Ingram & Morris, 2007).

Homophilous interactions, of course, have their benefits. Communication can be easier and more enjoyable with those who resemble us; and connecting with similar others can provide social support and a sense of shared identity (Byrne, 1971). The downside, especially in work organizations, may be that connections with similar others restrict the information available to an individual and can potentially splinter the organization into factions (Kane, 2015). Moreover, individuals' preference for similar others can produce informal status hierarchies in organizations,

arbitrarily placing some individuals in central network positions while relegating others to the network's margins (Blau, 1968; Lincoln & Miller, 1979). To be sure, empirical evidence for the relationship between network homophily and workplace performance at the individual level is sparse and mixed (e.g., Gompers, Mukharlymov, and Xuan, 2012; Ertug, Gargiulo, Galunic, & Zou, 2018). Nonetheless, workplace homophily is often criticized for reducing individuals' access to informational diversity (e.g., Ibarra, 2007; Uzzi and Dunlap, 2005; Kane, 2018) and is a widely cited reason for why women tend to lack access to central positions in workplace social networks (e.g., Brass, 1985; Casciaro & Piskorski, 2005; Ibarra, 1992).

It is precisely because workplace social networks are so often stratified on the basis of gender and rank that enterprise social media (ESM) has been getting such a warm reception in work organizations. ESM platforms are computer-mediated tools that allow users to "create, circulate, share, and exchange information in a variety of formats and with multiple communities" (Leonardi and Vaast, 2017: 150)[1]. Whereas traditional communication technologies in organizations, such as telephone or email, can be thought of as a channel though which communication travels, ESM are better characterized as a platform upon which social interaction occurs (Leonardi, Huysman, and Steinfield, 2013: 2; Kane et al., 2014). ESM platforms have the potential to radically reshape social interactions in the workplace by making it easier for people to learn who knows what and who knows whom, thereby facilitating communication and collaboration throughout the organization (e.g., Leonardi & Vaast, 2017; Qureshi, Fang, Haggerty, Compeau, & Zhang, 2018). However,

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[1] ESM can be defined more formally as "web-based platforms that allow workers to (1) communicate messages with specific coworkers or broadcast messages to everyone in the organization; (2) explicitly indicate or implicitly reveal particular coworkers as communication partners; (3) post, edit, sort text and files linked to themselves and others; and (4) view the messages, connections, text, and files communicated, posted, edited and sorted by anyone else in the organization at any time of their choosing" (Leonardi, Huysman, Steinfield, 2013:2; for a similar definition, see Kane et al., 2014).

while it is true that ESM provides individuals with the potential to easily connnect with diverse others, it is also true that ESM enables individuals to easily identify and connect with similar others. It is, therefore, unclear whether the ESM-based networks of organizational employees will in fact be unmarked by the propensity towards homophily that has been so extensively documented in employees' (offline) workplace social networks (Ibarra, 1992; Kleinbaum, Stuart, & Tushman, 2013; Ertug et al., 2018). Rather than enhancing network diversity, enterprise social media could make social networks more homogenous, creating self-reinforcing echo chambers (Leonardi, Huysman, & Steinfield, 2013). Similarly, ESM offers the potential to lower the barriers that can keep women and low-ranking employees from attaining more central positions in workplace social networks. This is because ESM platforms allow people to more easily learn about other individuals, irrespective of their gender or rank, making it easier to forge connections with a broader range of others. However, it is possible that a preference for interaction with high-status others might reinforce rather than erode the central positions of those who already enjoy relatively high status in organizations. These opposing possibilities have been discussed in previous work but they have rarely been subjected to a rigorous empirical test (see the discussion in Leonardi and Vaast, 2017: 171-172).

In this paper, we contribute to the sparse literature on network homophily in enterprise social media networks by examining how gender and rank shape the content and structure of employees' social networks. Our study examines approximately 540,000 messages exchanged between 2085 users of TamTamy, an ESM platform designed to enhance collaboration and information sharing among the employees of a large multinational corporation. We focused on the effects of gender and organizational rank on two aspects of the emergent social networks on the ESM platform: homophily; and centrality in the organization-wide ESM network. ESM platforms

"afford the visibility and persistence of communicative actions," making it possible for people to forge a broad range of connections and access central positions in social networks (Leonardi, Huysman, & Steinfield, 2013:3). However, both scholarly and practitioner-oriented reports have noted the possibility that ESM may in fact amplify the tendency towards homophily and lead to highly stratified networks. The overarching goal of our paper, therefore, is to present a theory-driven test of how gender and rank shape the content and structure of ESM-based social networks.

THEORY

How are gender and rank likely to shape emergent social networks on ESM platforms? The approach we take to this question builds directly on the conceptual framework presented in Leonardi and Vaast (2017). Briefly, we argue that ESM platforms possess a number of material features—such as the ability to post content and comment or share each others' content; or the ability to track who is connected with whom—that are different from those offered by previous communication technologies used in the workplace. These material features afford possibilities for actions that would otherwise be difficult or impossible to achieve. There are distinctive affordances provided by ESM platforms that are especially relevant to our inquiry. ESM provides user profiles that reveal the organizational identity of the user, including the user's gender and rank; and ESM provides people visibility into the interests and communicative actions of others, allowing people to infer who knows what and who is connected to whom.

On the one hand, it could be argued that the social networks people forge on ESM platforms will be inclusive, cutting across the barriers of rank and gender that stratify much face-to-face interaction in work organizations. The increased knowledge one can gain about the interests and connections of others should make it easier for people to connect with diverse others. For example, respondents in a study of the use of ESM in a large, global IT firm found that ESM made it easier

for people to forge new connections with people they would otherwise have had difficulty learning about and connecting with (Jackson, 2007). Similarly, a study that examined social networks in a large virtual world of online games (Huang , Yu, & Karimi, 2014), and a different study that examined interactions on MySpace (Thelwall, 2009), found no evidence of gender-based homophily. A more recent study of IT-mediated social interactions in a high-tech firm found that IT-mediated socialization helped people build connections with heterogenous others (Qureshi et al., 2018). Much of this evidence is merely sugestive, of course, because it comes from public social media rather than private ESM—the social networks that emerge on ESM may be quite different from those that emerge on public sites (see the discussion in Leonardi, Huysman, & Steinfield, 2013:4-6).

On the other hand, it can be argued that online social networks make it easier for people to identify and interact with similar others, so networks that emerge on ESM platforms will be especially marked by homophily. Illustrative evidence in support of this perspective is reported in one study of roughly 300,000 players in an online combat game that found that gender-based homophily strongly shaped social networks (Szell & Thurner, 2013); and a different study that used data gleaned from Tuenti, a Spanish social network platform, found that women were more homophilous than men (Volkovich, Laniado, Kappler, & Kaltenbrunner, 2014). Studies examining the effects of rank on ESM-based social networks are rare. A notable exception is an organizational study of 1386 social media users (Kim & Kane, 2015), which found mixed support for rank-based homophily. ESM gives organizational members the potential to diversify their social networks but it is unclear to what extent this potential is in fact realized.

We argue that rank and gender are both highly salient features of work organizations that are likely to shape the ties that individuals forge on ESM platforms[2]. Individuals are more likely to connect with others of the same organizational rank on ESM platforms because similarity in rank signals similarity in underlying interests and views—people of the same rank tend to have access to similar information and face similar opportunities and challenges. This presumption of similarity is likely to promote connectedness between those of the same rank on ESM-based networks just as they do in face-to-face networks (Ibarra, 1992; cf. Hambrick & Mason, 1984). Gender, too, is a salient attribute of users not just in face-to-face encounters but also online. We know from social psychological research that gender is a master category that people use to build expectations about the other (e.g., Ridgeway, 2011). In work organizations, women tend to face a host of common challenges—e.g., implicit and explicit biases stemming from negative social stereotypes about the abilities of women; and similar political obstacles to career success—that are likely to imbue women with a shared identity and sense of similarity (Tsui & O'Reilly, 1989). Our baseline expectation is that individuals are more likely to be connected to same-gender others on ESM-based networks, just as they tend to be in traditional workplace networks (Ibarra, 1992).

Distinctiveness Theory

Homophily implies a preference for interaction with similar others, but this leaves the basis of similarity undefined. In any organizational context, there are innumerable attributes that could become the basis for interpersonal attraction. It makes intuitive sense that gender and rank might be the basis for homophily in work organizations, given the general salience of these attributes in organizational life. However, homophily theory provides no basis for deciding which of these two attributes is likely to matter more in a given situation. Here we draw on "distinctiveness theory"

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[2] As on most ESM platforms, a person using the ESM we observed could discern the gender (and rank) of any other user by examining the profile picture, name, and bio of any other user.

(McGuire et al., 1978; McGuire, 1984), which argues that people in a social context are more likely to notice and affiliate with others with whom they share a characteristic that is relatively rare in that context. A pair of women in a group composed predominantly of men will, from the perspective of distinctiveness theory, be more likely to notice and identify with one another on the basis of their gender than would a pair of women in a group composed predominantly of women. Distinctiveness theory suggests that numerical rarity triggers perceptual salience; and this enhanced salience leads to a pattern of emphasized homophily.

HYPOTHESES

Homophily in ESM-based Social Networks

Drawing on distinctiveness theory, previous research on offline social networks has found that the members of numerically underrepresented groups, relative to members of the majority group, exhibit a stronger tendency to form within-group contacts (e.g., Leonard, Mehra, & Katerberg, 2006). We anticipate that this pattern of affiliation driven by numerical distinctiveness will also be found in the social networks that emerge on ESM platforms. The visibility and traceability of connections afforded by ESM platforms mean that users are confronted with a large, perhaps overwhelming, number of people to connect with and monitor. Yet there are cognitive limitations to the number of people and connections that humans can manage (Dunbar, 1992; cf. Simon, 1997). Given these attentional limitations, individuals faced with the potential to connect with a large number of individuals on an ESM platform are likely to rely on heuristics to decide how to allocate attention and time to a more limited set of individuals (Leonardi, Huysman, and Steinfield, 2013: 12). To the extent that human cognition relies on an underlying tendency to focus on attributes that are numerically rare in a given setting, as suggested by the theory of

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distinctiveness, we can anticipate that numerical rarity will be such a heuristic and will predict patterns of homophily in ESM networks.

The theory of distinctiveness suggests that the tendency towards homophily is not fixed and immutable; rather, it changes predictably as a function of the relative proportions and kinds of people present in a setting (McGuire et al., 1978). To derive predictions based on distinctiveness theory, therefore, the researcher must first take note of the make-up of the sample (see, e.g., Leonard, Mehra, & Katerberg, 2006). In the sample of TamTamy users observed in this study, women (22%) were significantly underrepresented relative to men (78%); and higher-ranking individuals (19%) were significantly underrepresented relative to lower-ranking individuals (81%). This distribution, moreover, was relatively constant over the three years covered by our sample— although the number of total users increased each year, the percentage of users in each of the categories of interest did not change (see Table 1).

Our first set of hypotheses are based on the expectation, derived from distinctiveness theory, that the tendency towards homophily will be stronger among individuals who belong to a group that is relatively rare. When an individual shares a characteristic that is numerically distinctive in a given setting, that individual is especially likely to notice the characteristic and use it, consciously or unconsciously, as a basis for connecting with others. In the empirical setting of ESM platforms, the logic of distinctiveness theory predicts that the networks of the individuals who are in the numeric minority (in our sample: women; and high-ranking individuals) will tend to exhibit a stronger tendency towards homophily than individuals who are in the numeric majority (men; and low-ranking individuals).

Hypothesis 1a: The ESM based networks of women (relative to those of men) will exhibit

greater gender-based homophily.

Hypothesis 1b: The ESM based networks of high-ranking individuals (relative to those of

low-ranking individuals) will exhibit greater rank-based homophily.

Most studies of homophily tend to ignore the fact that people simultaneously possess

multiple attributes (e.g., a person may be a woman and a high-ranking person in the firm). Even if

we expect to find evidence of both gender-based and rank-based homophily, the question remains

as to which of these two bases for homophily is likely to be more salient and therefore a more

potent basis for connecting with others on ESM platforms. Distinctiveness theory suggests an

answer: for any given individual, the characteristic that is relatively rare is likely to be more salient,

and, therefore, is more likely to serve as a basis for connecting with others.

Given the composition of our sample (see Table 1), this reasoning allows us to make several

fine-grained predictions. First, from the perspective of distinctiveness theory, we can expect that for

high-ranking men, rank will be a more important than gender as a basis for connection. This is

because it is rank (19% high-ranking) rather than gender (78% men) that is the rarer atrribute for

high-ranking men.

Hypothesis 2a: The ESM-based networks of high-ranking men will exhibit greater rank-

based homophily than gender-based homophily.

However, for low-ranking men, distinctiveness theory would suggest that neither gender nor

rank will be particularly salient as a basis for connecting with others on ESM-based networks. This

is because low-ranking men are in the numeric majority with regard to both rank (and gender.

Second, distinctiveness theory would suggest that for low-ranking women, gender should be a more likely basis for connecting with others on ESM-based networks than rank. This is because the rarer attribute for a low-ranking woman in our sample is her gender (19% women) rather than her rank (81% low-ranking).

> Hypothesis 2b: The ESM-based networks of low-ranking women will exhibit greater gender-based homophily than rank-based homophily.

For high-ranking women, distinctiveness theory would suggest that neither gender nor rank will be particularly salient as a basis for connecting with others on ESM-based networks. This is because high-ranking women are in the numeric minority with regard to both their rank (19% high-ranking) and their gender (19% women).

Gender, Rank, and Network Centrality on ESM Platforms

Much of the excitement around ESM platforms has to do with the potential they offer for workers to connect across both the formal divisions of rank and the informal divisions that arise as a function of visible, status-laden attributes like gender. Although research has found strong evidence that high-ranking individuals tend to occupy more central positions in organization-wide social networks (e.g., Lincoln & Miller, 1979; Miller, 1986; Brass, 1985; Burt, 1992), and somewhat mixed evidence of women's tendency to be on the margins of these networks, it is unclear whether these differences in access to central positions will persist on ESM-based networks. To the extent that the affordances of ESM can act as a kind of "social lubricant" that facilitates the attainment of social capital because social connections are "easier to create when people know what others are doing" (Leonardi, Huysman, & Steinfield, 2013: 15), it is possible that ESM platforms will enable a rewiring of organizational social networks, giving those who have traditionally been excluded from central positions in social networks a better chance of gaining access to the network's center. The

affordances of ESM make who knows what and who knows whom visible, thereby making it possible for those in the minority to better access central positions on ESM networks through strategic networking (Kane et al., 2014). A more pessimistic view might argue that low ranking individuals and women will continue to have difficulty accessing centrality in ESM-based networks, albeit for different reasons. Typically, low ranking individuals are in the numeric majority and therefore rank is not a strong basis for connecting with others for low ranking individuals. Low ranking individuals are also less likely to command resources, making them less attractive as partners in a work setting (Lin, 2001). This would mean that low ranking individuals will continue to be relegated to the margins on ESM-based social networks.

It is possible, of course, that individuals may engage in impression management on ESM platforms. Some high ranking individuals may connect with low ranking so as to avoid the appearance of elitism. Similarly, because women generally tend to have lower perceived social status in work organizations and tend to be less likely to be in high-ranking positions, it seems reasonable to expect that women will be less likely (than men) to attain central positions in organization-wide networks. Nonetheless, it is also possible that women might gain access to more central positions in ESM-based networks: Those in central network positions may be more inclined to connect with women on ESM media because such connections do not involve much of a cost and yet create a positive image in the eyes of others.

Given these competing theoretical possibilities, and the paucity of prior empirical work grounded in ESM, it would be overstating the current state of knowledge to advance formal hypotheses related to rank, gender and access to positions of centrality in organization-wide networks. Instead, here we simply formulate for empirical test the question: To what extent is centrality in organization-wide social networks on ESM platforms stratified by rank and gender?

METHODS

Data Processing and General Statistics

The data for our study come from TamTamy, an enterprise social media tool, that was designed by Reply[3], an international network of specialized companies in the field of digital services. Reply used TamTamy to help create learning and collaboration communities online where employees could easily share knowledge and develop new ideas. TamTamy, like other popular enterprise social media (e.g., Jive[4]) provided users with a collaboration space to share knowledge and documents, communicate with co-workers, and search for relevant content and people within the company.

Although the TamTamy platform provides a number of services, we are concerned here with the social networking and communication functions it offers. Messages are started by a thread initiator (hereafter referred to as the *author*). The other users (*commenters*) are then free to contribute with answers, and to rate messages with like and dislike, in much the same manner as Facebook. The basic format of each thread is the following:

thread_id, thread_title, thread_author,[SEP] timestamp, thread_tags,[SEP] author_title,

author_gender(0=male,1=female),thread_content,{comment_id,commenter,commenter_title,

commenter_gender, timestamp,comment_content,$\}^{n}$

The thread tags are free, although there exist a number of pre-defined tags. The field *title* indicates the author/commenter organizational rank in the company (manager, consultant, senior

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consultant, partner, external, content publisher). The gender of authors and commenters is also available.

In our study, we used a three-years anonymized dataset of employees' messages, which was made available to us by Reply as part of a consulting project. Because threads were associated with a time stamp, the network could be generated and analyzed with reference to a time interval, T, considering only the threads observed during that time interval. The six work roles within the company were re-grouped into two meta-roles to get at organizational rank: *executive/high-rank* (manager or partner) versus *employee/low-rank* (all the remaining four roles).

On TamTamy, starting a thread was— except for designated "content publishers," who made up a small minority of users—not a role obligation. Because the online behaviors of content publishers are biased by their work mission (they are expected to animate the network and to post content), we removed individuals who were in the "content publisher" role from the analysis. Some messages were intended solely to broadcast information—they did not provide a basis for soliciting comments or contributions from other users. We therefore restricted our analysis to threads that generated at least one comment (denoted as non-zero threads). We manually verified on a data sample that the large majority of non-zero threads include discussions on a variety of technical and organizational issues.

After this filtering phase, we were left with over 100,000 threads from 2273 different users. Table 1 shows some general statistics on the network, split in three time intervals, one for each year.

Table 1 – Summary Statistics of the TamTamy dataset

	Year 1	Year 2	Year 3	Total (different users) over 3 years

Active Users	735	1070	1505	2273
Females (%)	167 (23%)	214 (20%)	309 (21%)	486 (22%)
Males (%)	568 (77%)	856 (80%)	1196 (79%)	1760 (78%)
Executives (%)	166 (23%)	258 (24%)	305 (20%)	429 (19%)
Employees (%)	569 (77%)	812 (76%)	1200 (80%)	1817 (81%)

As shown in Table 1, women users comprised between 20% and 23% of all users during the three years in the observation period (2012-2014), and executives between 19% and 23%. Women were underrepresented relative to men in all three years; executives were underrepresented relative to employees in all three years.

Homophily

There are a number of different approaches to measuring homophily in large online social networks. For example, Bhattacharya and colleagues (Bhattacharya, Zafar, Ganguly, Ghosh, & Gummadi, 2014) used Twitter lists to first deduce the topical expertise of popular Twitter users, and then transitively inferred the interests of the users who follow them. Similarly, Colleoni, Rozza and Arvidsson (2014) used tweets to determine users' political orientations, which they then used to compute an overall measure of homophily. Zamal, Liu, and Ruths (2012) used lexical and structural features of users' messages to derive their gender, political orientation and age, which were then used to derive homophily. A different set of network-oriented studies has attempted to measure homophily as similarity between users in terms of the structural features of their networks, such as its size. Homophily in these studies is often referred to as "assortativity" (Newman, 2003; for a review, see Noldus & van Mieghem, 2015).

One of the problems with the standard formulation of assortativity is that it provides a global

measure of homophily for the overall network. An approach better suited to the questions we address in this paper has been presented in Golub and Jackson (2012), where homophily is defined as the expected number of links a node of type k will have with nodes of type j, divided by the expected degree of a node of type k. The authors apply this model to a special case, denoted as *island model*, where each type has the same number of nodes and any agent only distinguishes between agents of one's own type and agents of a different type. Furthermore, all agents are symmetric in how they do this. In this paper, we adopt a similar multi-type network approach, where homophily is measured as a function of the difference between the amount of observed interaction between nodes of different types and the expected interaction in absence of homophily.

We now explain our approach to assessing node-level homophily. First, we note that, in a thread-based model, authors post a message without specifying the addressee. Consequently, only the action of commenting on a message can be influenced by the gender and/or organizational rank of the author. For any user u, we define the following set of partly overlapping types[5] to which he/she may belong:

C=$\{female, male, \ exec, empl, female - exec \ , male - exec, female - empl, male - empl\}$

Definition (affinity): We define the $i \rightarrow j \ affinity$ as the probability that a commenter belonging to type $c_i \ \in C$ comments a thread initiated by an author belonging to type $c_j \in C$:

$$i \rightarrow j \ affinity = \ \Pr\big(c_i - commenter \ \rightarrow c_j - author \ / \ c_j - author\big) = \ P_{i \rightarrow j}$$

If no affinity exists between commenters of type c_i and authors of type c_j, there will be no statistically significant difference between $P_{i \rightarrow j}$ and the prior probability that an author belongs to type c_j. In other words, the commenter will decide to answer a thread regardless of the type of the

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author. The <u>null hypothesis</u> H0 (*neutrality*) for $i \rightarrow j \; affinity$ is then:

$$H0: d_{i \rightarrow j} = Pr\left(c_i - commenter \; \rightarrow c_j - author \, / \, c_j - author\right) - \Pr\left(c_j - author\right)$$

$$= \; P_{i \rightarrow j} - P_{j-author} = 0$$

H1 (*affinity*) is when $d_{i \rightarrow j}$ is significantly[6] higher than zero. Note that *homophily* is defined here

as a special case of $i \rightarrow j \; affinity$, i.e., when $c_i = c_j$, and is tested by computing $d_{i \rightarrow i}$.

Data Analysis and Results

To test affinity between different type pairs, we first split our dataset in 12 intervals T_k of 3

months each. We verified that this is a sufficient granularity to analyze the dynamics of the

enterprise social network during the considered period, while ensuring a sufficiently large number

of exchanged messages and users in each interval T_k.

For any interval T_k, we compute $d_{i \rightarrow j}$ for selected types *i* and *j*, (e.g.: $female\_exec \rightarrow$

emp) and we compare the estimated value with the null hypothesis $d_{i \rightarrow j} = 0$.

We denote by $n_1, .. n_k, .. n_K$ the size of the users' population[7] in each interval $T_1..T_K$, with

$v_1, .. v_k, .. v_K$ their respective variance for the random variable $d_{i \rightarrow j}$, and with N i the size of the

population without overlap.

We compute the *pooled variance*[8] as follows:

$$v_p = \frac{(n_1 - 1)v_1 + \; (n_2 - 1)v_2 + \cdots + (n_K - 1)v_K}{N}$$

and the *standard deviation* as $sd_p = \sqrt{v_p}$

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[6] According to a two-tail significance test

[7] In any interval, the population size n_k is the number of commenters belonging to the observed type c_i.

[8] https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Pooled_variance.html

Finally, to accept or reject H0 in each T_k, we compute the 95% two-tail confidence intervals $\pm Z_{\alpha/2} \times \frac{sd_p}{N}$.

RESULTS

Homophily

In the following graphs, for each $i \rightarrow j \; affinity$ measurement, the straight line denotes the null hypothesis H0 ($d_{i \rightarrow j} = 0$) , the dashed lines are the upper and lower bounds for accepting H0, and the broken line plots the observed values for $d_{i \rightarrow j}$.

Our first pair of hypotheses used distinctiveness theory to argue that the tendency to connect with similar others would be stronger among members of the group that is in the numeric minority. According to hypothesis 1a, the tendency to connect with same-sex others would be stronger among women than men. The results presented in Figure 1 shows that there was no significant tendency towards gender homophily among men. Figure 2, by contrast, shows a significant tendency towards same-sex contact among women. The findings presented in Figures 1 and 2 support Hypotheses 1a.

According to Hypothesis 1b, the tendency towards connecting with others of the same organizational rank would be stronger among high-ranking individuals than among low-ranking individuals. The results presented in Figure 3 and 4 show that the tendency towards connecting with same-rank others was significant among high-ranking (executive) individuals and insignificant among low-ranking individuals. Hypothesis 1b was supported.
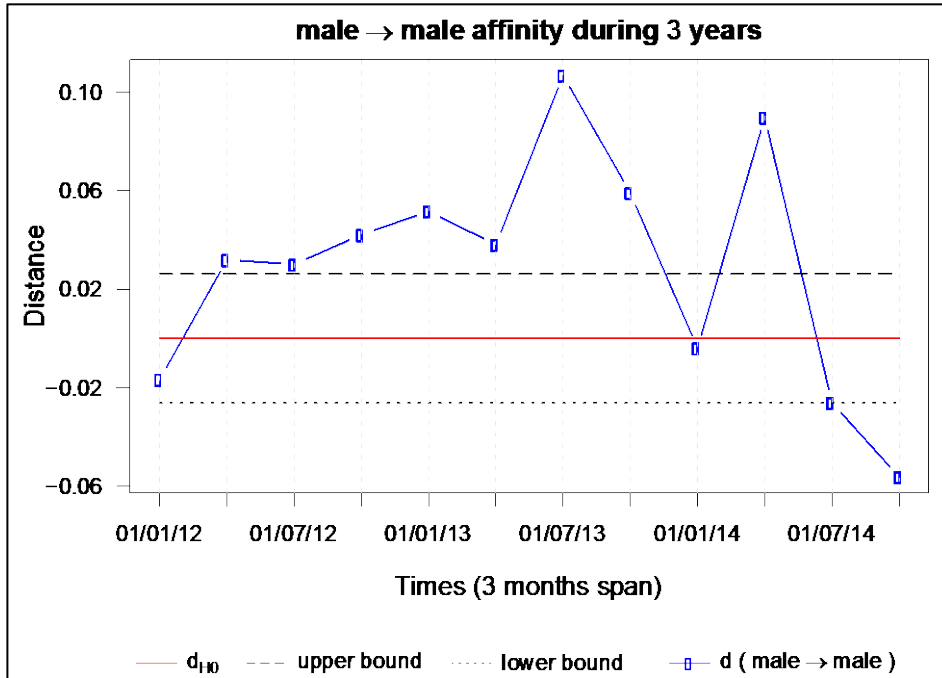
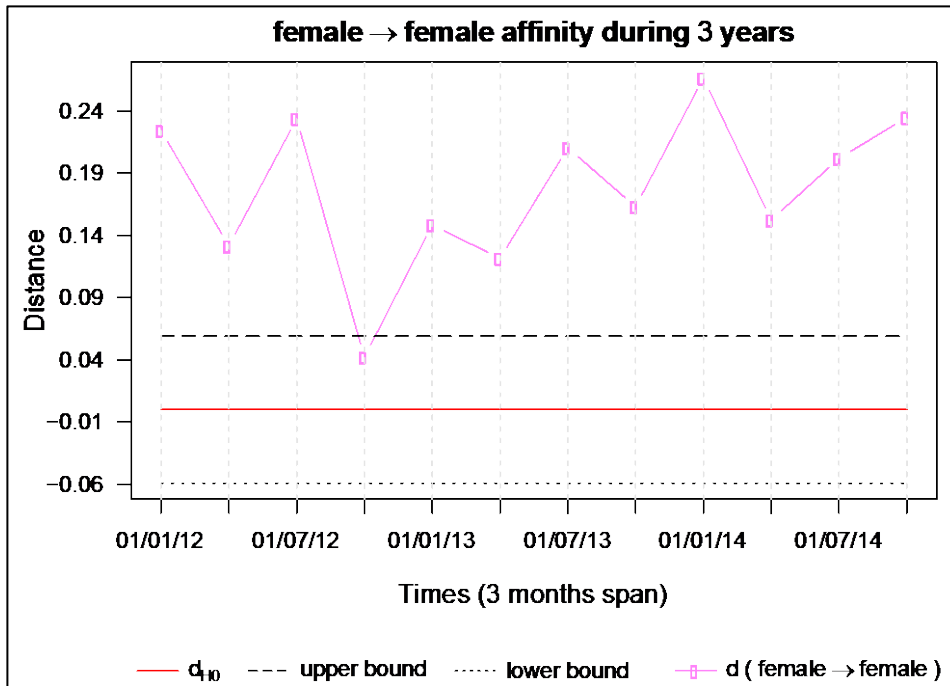**Figure 1.** Tendency among men to connect with other men

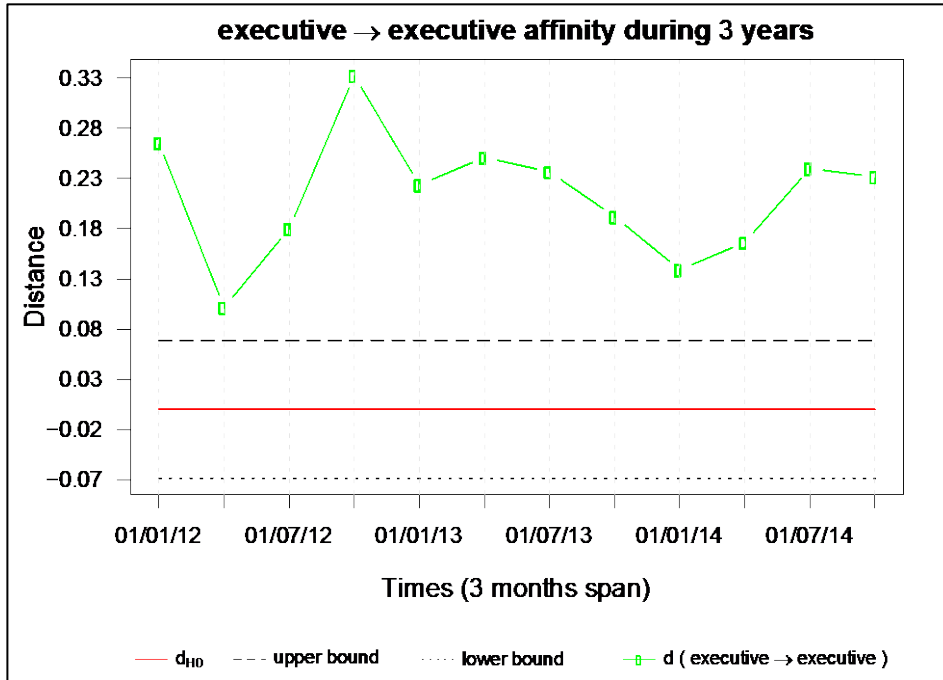**Figure 2.** Tendency among women to connect with other women

Figure 3. Tendency among executives to connect with other executives
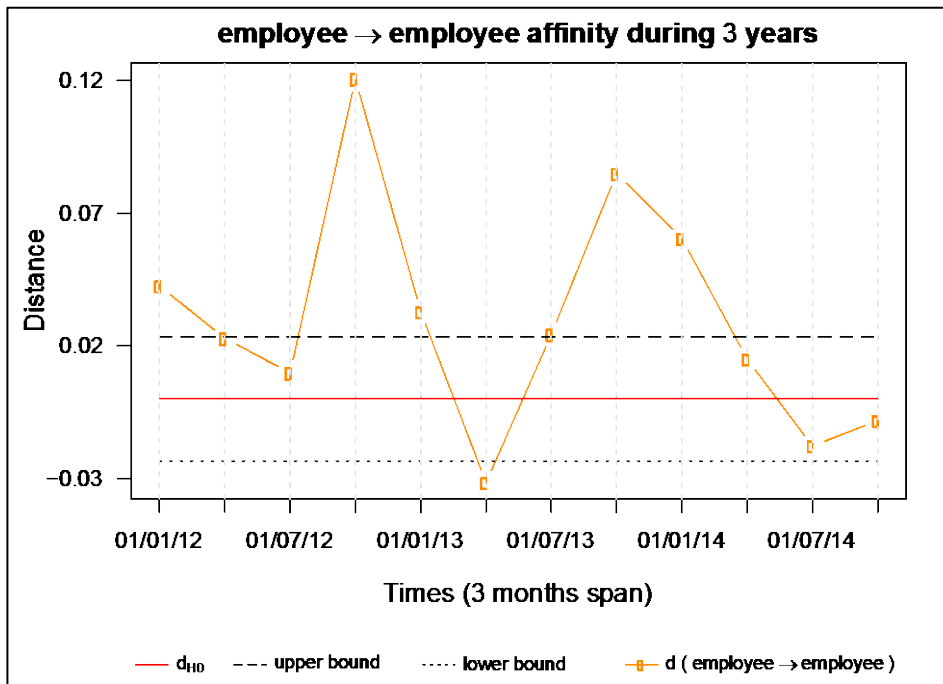

Figure 4. Tendency among employees to connect with other employees

Hypothesis 2a predicted that the enterprise social media-based networks of high-ranking men would exhibit greater rank-based homophily than gender-based homophily. Consistent with this hypothesis, Figures 5 and 6 show that high-ranking (executive) men were likely to connect with others on the basis of rank; and Figure 7 shows that, for high-ranking men, gender was not a significant basis for connecting with others. These results show support for Hypothesis 2a. Similar analyses not presented here but available upon request showed, as anticipated by distinctiveness theory, that for low-ranking (employee) men, neither rank nor gender proved a significant basis for connecting with others.
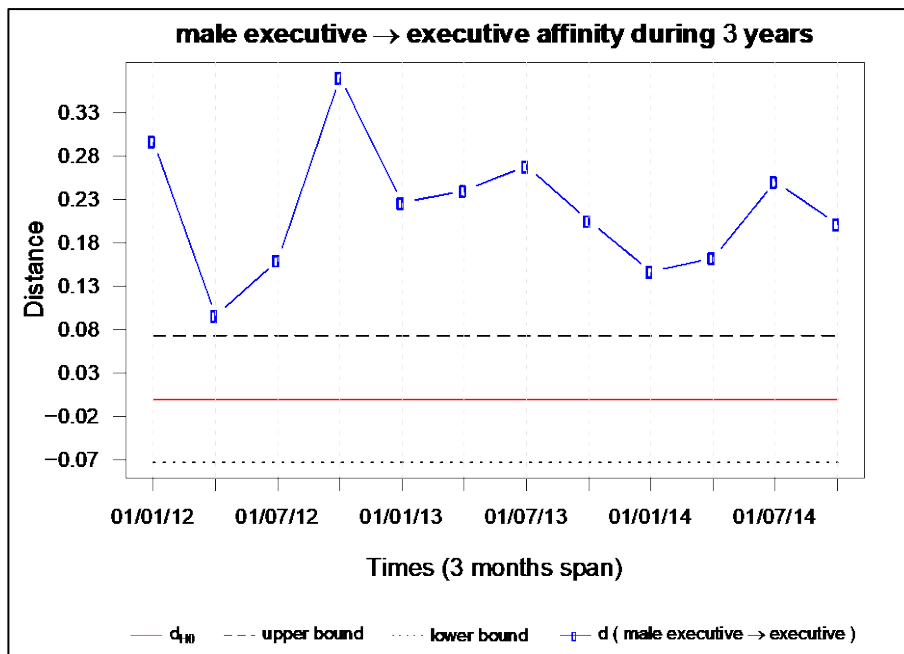

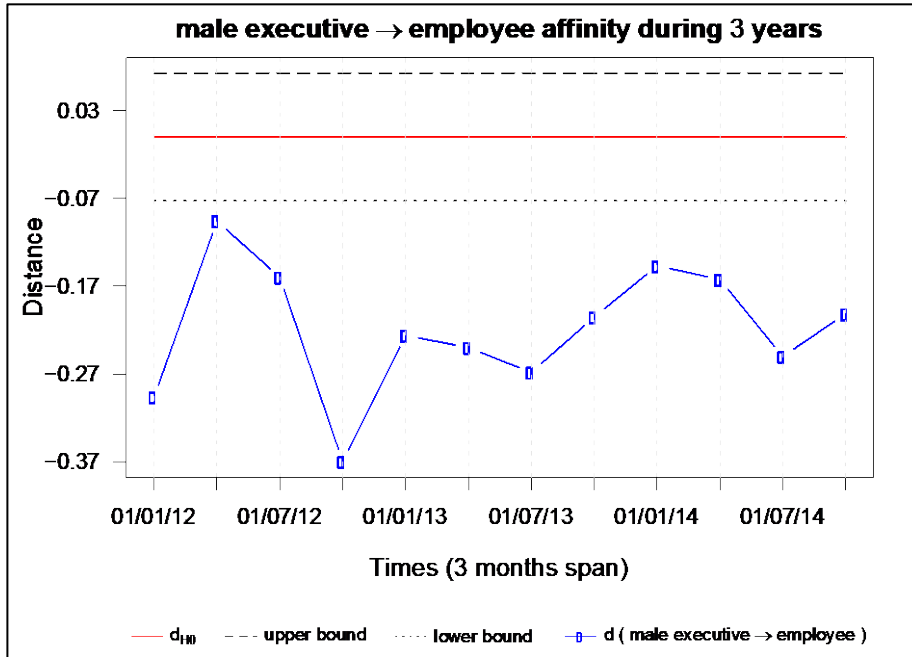**Figure 5**. Tendency among executive men to connect with other executives

22

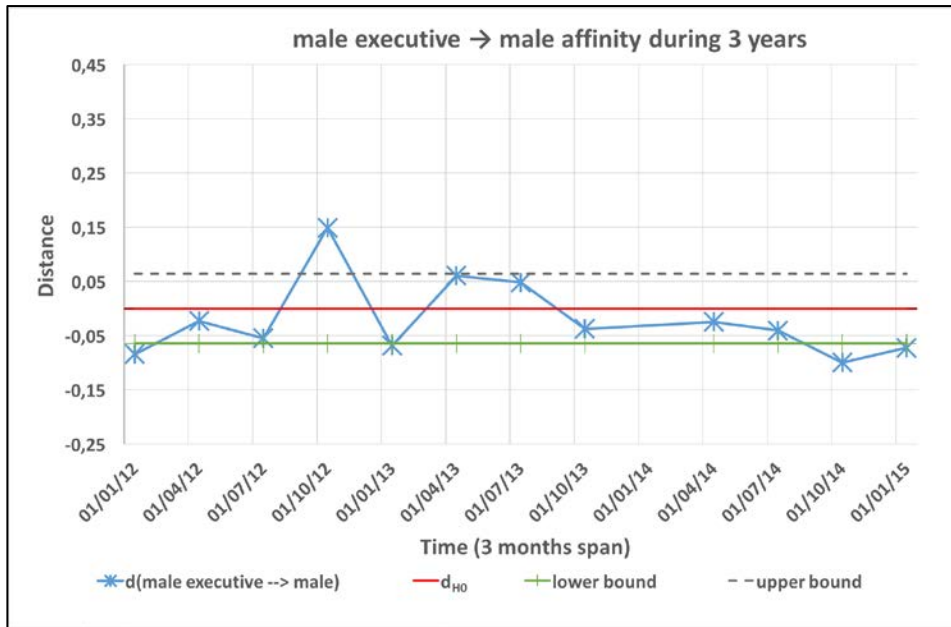**Figure 6**. Tendency among executive men to connect with employees

. **Figure 7**. Tendency among executive men to connect with same-gender others

Hypothesis 2b predicted that the ESM-based networks of low-ranking (employee) women would exhibit greater gender-based homophily than rank-based homophily. Figure 8 shows that low-ranking women were more likely to connect with same-gender others. Figure 9 and 10 show, by contrast, that rank did not play a significant role in determining who low-ranking women were connected with. These results suppport hypothesis 2b. Moreover, in similar analyses not presented here but available upon request we found, as anticipated by distinctiveness theory, that for high-ranking women neither gender nor rank were a significant basis of connecting with others.
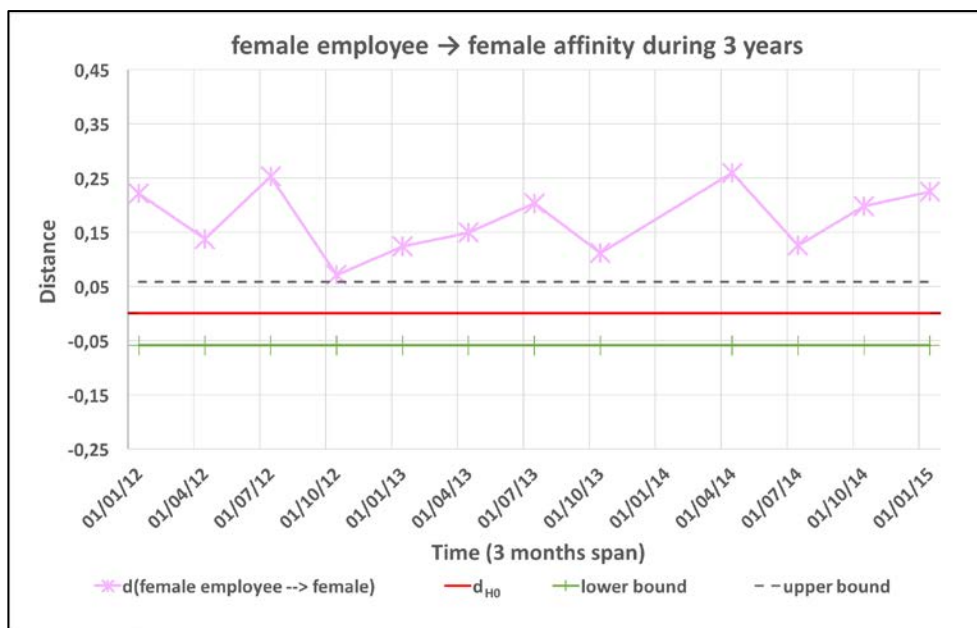

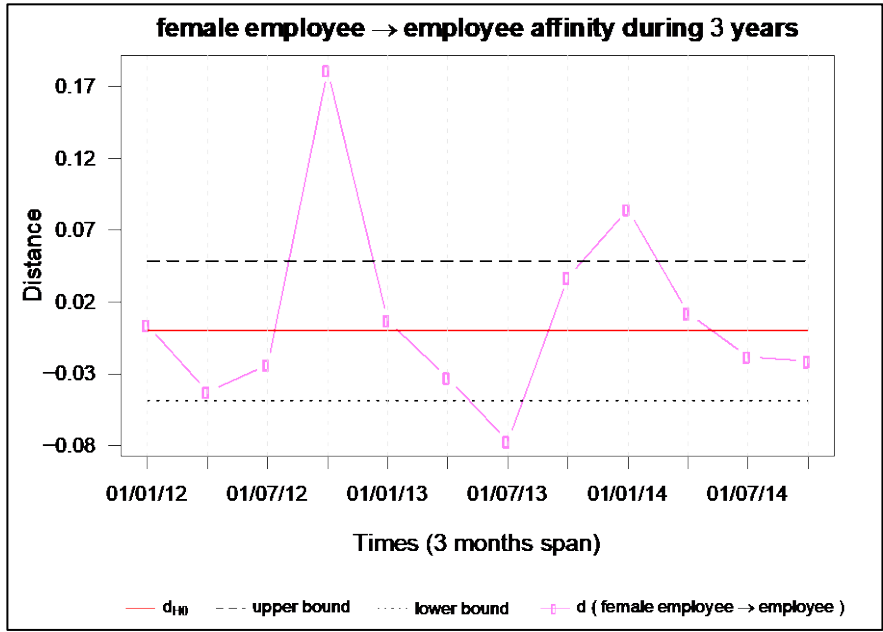**Figure 8**. Tendency among non-executive women to connect with same-gender others

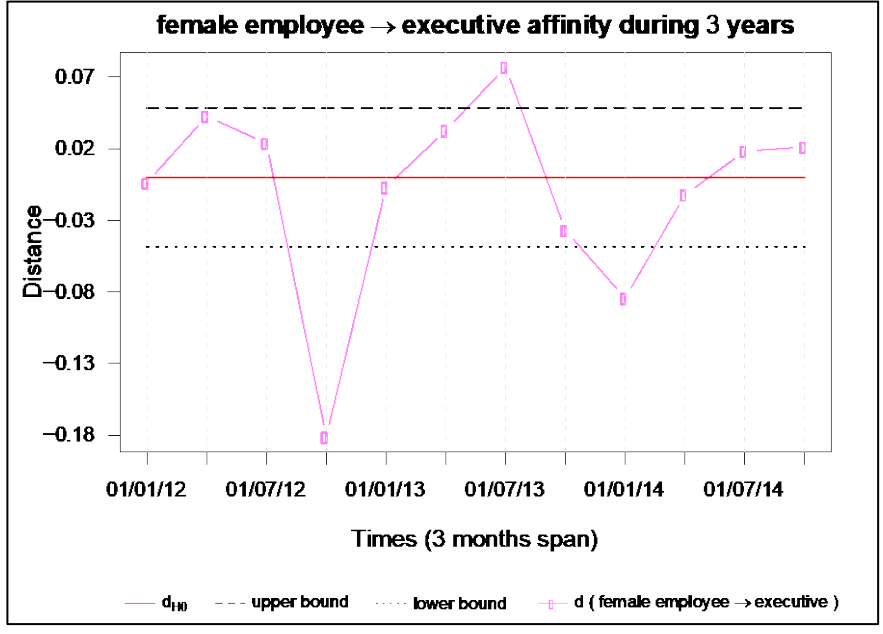**Figure 9**. Tendency among non-executive women to connect with other non-executives

Figure 10. Tendency among non-executive women to connect with executives

Network Centrality

Did gender and rank influence the centrality of individuals in the emergent network on Tamtamy? Network centrality can be conceptualized and measured in a number of different ways (Freeman, 1979). We examined two forms of organization-wide centrality in ESM-based social networks. The first approach we adopted computed eigencentrality values for all the nodes of the social network, where each weighted edge in the network $i \rightarrow j$ represents the number of times that user u_i commented a thread authored by user u_j. Because the edges are weighted, we used weighted Page Rank (Xing & Ghorbani, 2004) as our index of centrality. In the computer science literature, several papers have underscored the superiority of so-called eigenvector centrality measures (cf. Bonacich, 1987), like the Page Rank measure we used here, over simpler centrality measures, like degree. The Page Rank measure of centrality fits the intuition of a person who is central in organization-wide networks as a function of having a large network of contacts who are themselves well connected. Ding et al. (2009) have shown that the Page Rank measure is highly correlated with citations received in a co-citation network. As expected in scale free networks, eigencentrality values have a zipfian distribution, with very few users with a very high rank, and a long tail of users with relatively low rank. We split users into two groups (high centrality vs others) based on the second percentile, and then tested to see if there was a significant correlation between network centrality and gender, or between network centrality and rank. The results are presented in Figures 11 and 12, where the straight line is the percentage (prior) of users in the sample belonging to the controlled variable (gender, in Figure 11, and organizational rank, in Figure 12). Both Figures show that the distribution of users in the two PageRank ranges is not significantly different (p=ns) from the overall distribution of the sample in the considered categories (gender and organizational

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rank). These results indicate that neither gender nor rank had a significant effect on overall Page
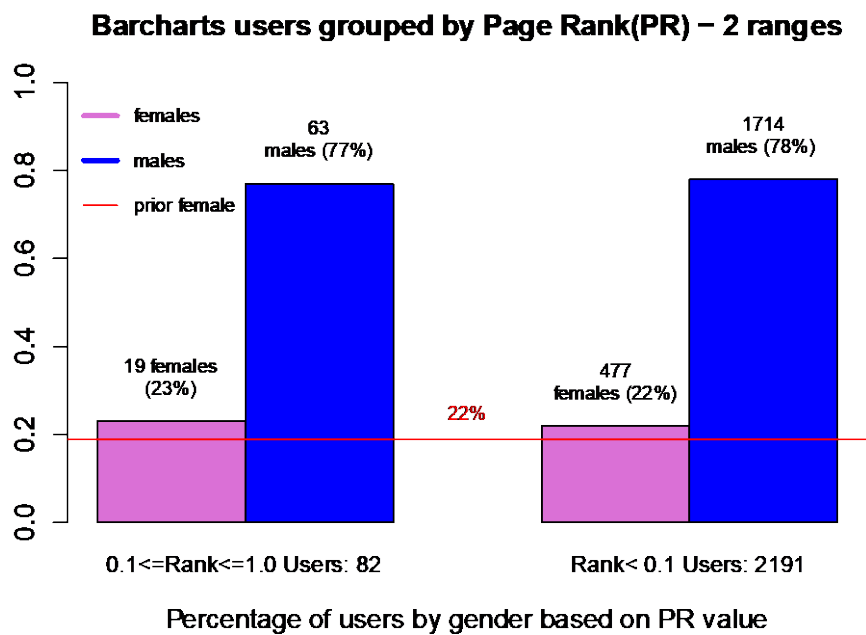
Rank centrality on Tamtamy.

Barcharts users grouped by Page Rank(PR) − 2 ranges

Percentage of users by gender based on PR value

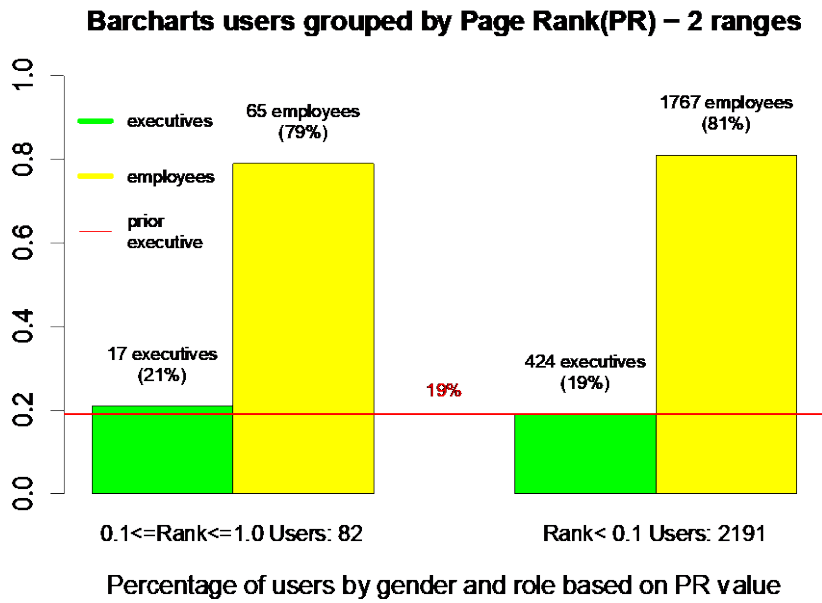**Figure 11.** Users grouped by PageRank and gender

Figure 12. Users grouped by PageRank and organizational role.

The second approach we used to measure centrality in organization-wide network sought to identify brokerage or bridging positions in the ESM-based network. Brokerage positions have been shown to be associated with performance, influence, and leadership in work organizations (Burt, 2005). To identify brokerage positions, we relied on the KPP-NEG algorithm (Borgatti, 2006). This algorithm identifies those nodes as central that, if removed from the network, would most fragment the networks (see the extended discussion in Borgatti, 2006).
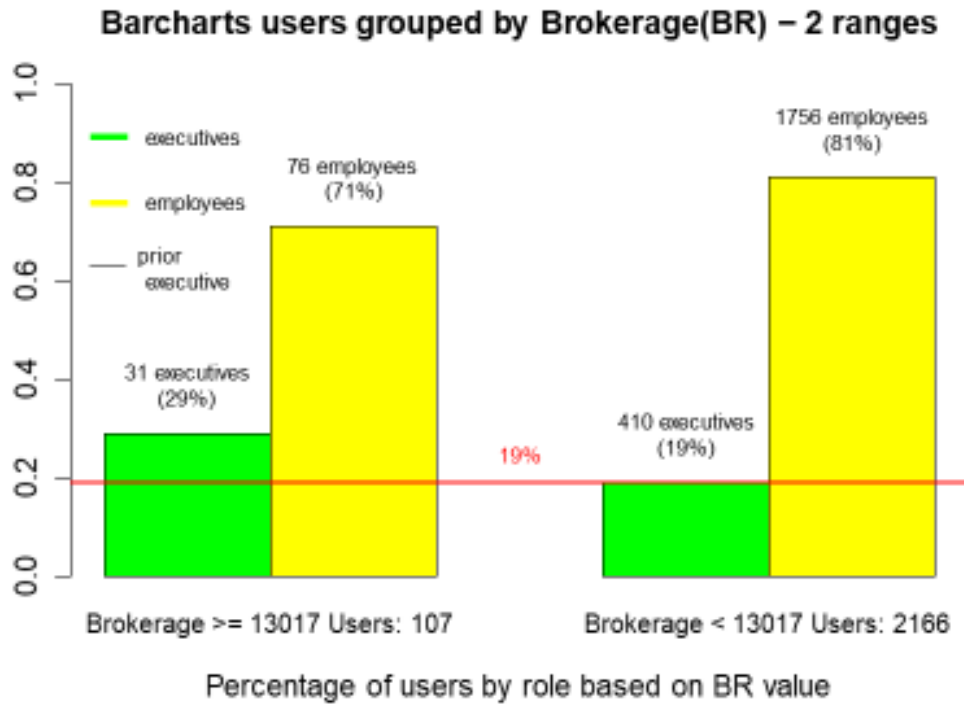
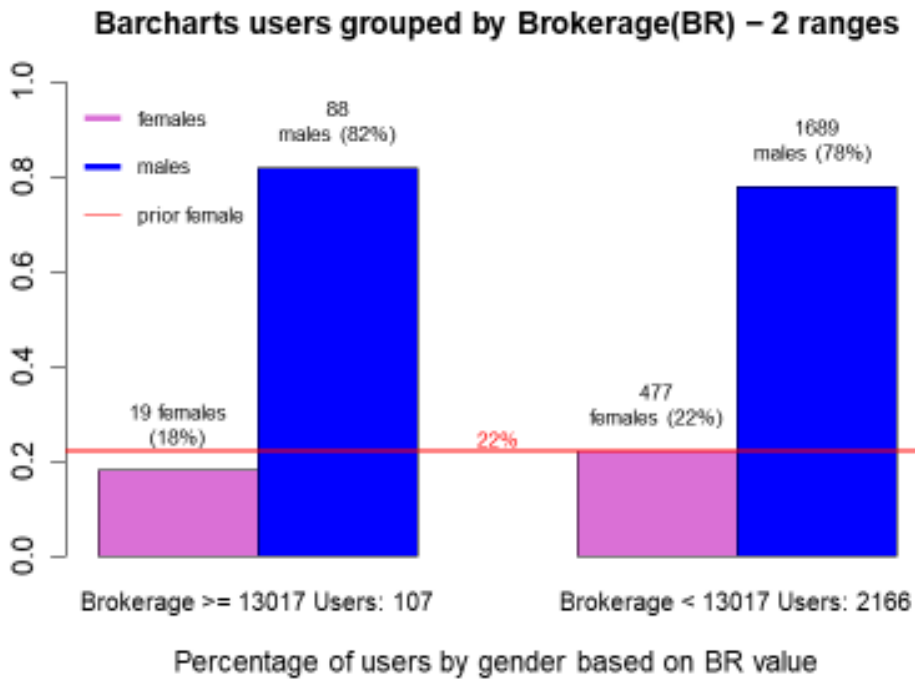**Figure 13.** Users grouped by KPP-NEG brokerage

Figure 14. Users grouped by gender and KPP-NEG brokerage

We again split users on the basis of centrality, this time using the KPP-NEG algorithm to compute brokerage centrality. As shown in Figure 13, executives tended to overrepresented in top brokerage positions relative to their overall representation (p<.015). Figure 14 shows that women were somewhat less likely to occupy central bridging positions in the ESM-based social network relative to the representation in the sample, but this difference was not statistically significant (p=0.358).

Overall, these results show that access to central positions on ESM-based social networks was not influenced by gender or rank, with one exception: high ranking individuals were more likely to emerge as brokers in ESM-based social networks.

DISCUSSION

Work organizations have begun adopting ESM in growing numbers in an effort to promote communication and collaboration across demographic and hierarchical boundaries. A key belief underlying this trend is that by making it easy and efficient to connect with virtually anyone in an organization, ESM can help rewire employees' social networks so that they are less marked by homophily and provide better access to central network positions to women and lower-ranking employees. The overarching goal of our paper was to submit this widespread assumption to a theory-driven test.

We examined approximately 540,000 messages embedded in 100,000 threads generated by 2273 users of TamTamy, an enterprise social media platform. Our study revealed considerable evidence of both rank-based and gender-based homophily in ESM-based social networks, consistent with our baseline expectation. Using distinctiveness theory, which argues that the numeric rarity of a category in a given setting promotes the use of that category as a basis for connecting with others, we hypothesized and found: (a) the tendency to connect with same-gender others was stronger among

women than among men; (b) the tendency to connect with same-rank others was stronger among high-ranking employees than among low-ranking employees; (c) for high-ranking men, rank was more important than gender as a basis for connecting with others; and (d) for low-ranking women, gender was more important than rank as a basis for connecting with others. We also found that whereas higher ranking individuals were more likely to be in central (bridging) positions in the overall network, gender was unrelated to network centrality. Our study suggests that the affordances of ESM for open and distributed communications notwithstanding, the social networks that emerge on ESM platforms may reinforce social stratification on some dimensions while diminishing it on others.

Implications for Theory and Research

Enterprise social media platforms present users with a wealth of options in terms of who to focus on and connect with, but there are limits to the number of people one can attend to (Dunbar, 1992) and there are limits to the amount of information one can take in (Ocasio, 1997). Given that attention, even on online social media platforms, is at a premium, our study suggests that people tend to connect with those with whom they share attributes that are numerically rare and therefore distinctive. The consequence of these social psychological processes is that rather than connecting broadly with similar and dissimilar others, individuals tend, as in offline workplace social networks, to build homophilous social networks stratified by gender and rank. Most of this virtual connectedness tends be emergent and self-organizing. The connections that take place on ESM can happen synchronously or over extended time horizons. Whereas much of organizational life is arguably well-represented as goal-oriented and purposeful, users on ESM may join conversations or respond to another user's content without necessarily understanding how their actions are helping shape and reinforce the structure of virtual communities making them at times "…unwitting actors in organizing processes they do not understand or of which they are unaware" (Leonardi & Vaast,

2017: 180). Our study adds to the nascent literature on emergent ESM-based networks the idea that social psychological theories, like distinctiveness theory, that anticipate how selective attention operates in information-rich environments to shape people's sense of identity and their propensity to connect with others can be useful in making sense of the content of emergent ESM-based social networks.

Our study contributes to the sparse literature on how gender and rank are related to centrality in ESM-based organization-wide networks. We found no evidence of gender-based differences in access to central positions in social networks. This finding contrasts with a number of previous studies of offline organizational social networks that have found evidence of gender-based differences in centrality (e.g., Brass, 1985); but it is consistent with others that have found no such difference (e.g., Mehra, Kilduff, & Brass, 2001). Similarly, there was no evidence that rank influenced access to central positions when centrality was defined on the basis of the Page Rank algorithm, which assigns high centrality scores to those who are connected to those who are themselves well connected. But when it came to centrality in the sense of occupying brokerage positions in the overall ESM-based social network, rank made a difference: High-ranking organizational members were more likley to emerge as brokers in the ESM-based social network.

Our study offers new insights that contribute to the ongoing work on distinctiveness theory. Early work on distinctiveness theory focused on the relative salience of attributes not on the implications of this salience for the actual connections people build with each other (e.g., McGuire et al., 1978). Research has since extended the reach of distinctiveness theory from its traditional roots in the study of social identity to that of actual social network ties in organizations (Mehra et al., 1998; Leonard et al., 2006). Our study is the first (that we are aware of) to use distinctiveness theory to study the patterns of connectivity that develop on ESM-based social networks. Although

women were more homophilous than men in the setting we examined, distinctiveness theory predicts that in a setting where men are in the numeric minority, it would be men, not women, who would show a greater propensity towards gender-based homophily in ESM- based social networks. Similarly, one could imagine a setting where high-ranking individuals outnumbered low-ranking ones. In such a setting, distinctiveness theory would predict that it would be low-ranking individuals whose networks would be more strongly shaped by the preference to connect with same-rank others. Similarly, the distribution of men and women across high-ranking and low-ranking positions in our setting was such that for for high-ranking men, it was rank rather than gender that was a significant basis for connecting with others. But had men been in the numeric minority in our sample, distinctiveness theory would predict that for high-ranking men it would have been gender not rank that would be a more important basis for connecting with others. Testing these predictions will require researchers to collect server-side data from organizations with atypical compositions (e.g., organizations where women are in the numeric majority). We expect to find that the effects of gender and rank on the content and structure of emergent ESM-based networks vary systematically as a function of relative numbers of men and women in high and low-ranking positions in the organization.

Given that the preponderance of studies of ESM have used inductive methods, scholars have explicitly called for research that complements prior work with insights that can best be gleaned by using server-side data (see Leonardi & Vaast, 2017: 182). One obvious advantage of server-side data is that it is less subject to recall bias and social desirability bias. Moreover, researchers can collect large samples of time-stamped data, which is a boon for advancing more dynamic theories of network emergence on ESM. On the other hand, it can be hard to interpret the psychological significance of ESM-based interactions for the people involved based solely on server-side data.

Our study makes an empirical contribution in offering a quantitative analysis of server-side data, but we recognize that to advance our understanding of the phenomenon, research needs to tack back and forth between different sources of data.

A practical implication of our study is that ESM-based social networks may require managerial intervention if they are to realize their potential for creating networks less stratified networks. Dashboard-based analytics could be used to help alert ESM users to emerging dysfunctions in their networks and prompt corrective action. A user could be alerted, for example, when her network starts to become overly homophilous. Similarly, it might be possible for enterprise social media to use recommendation systems to avoid individuals, perhaps unwittingly, splintering into non-overlapping sub-groups.

Limitations

We have focused exclusively in this study on the social networks that members of a work organization developed on an ESM platform. Our study does not include any data on the social network ties that individuals may have forged offline or via other social media. It is possible that the very people who had homophilous networks online on the ESM we studied had heterophilous networks offline. Future research might try to collect survey-based or interview-based social network data to complement the social network data obtained via social media servers. This task, however, would be challenging for large organizations with thousands of employees.

Our study did not distinguish ESM-based social connections in terms of geographic distance or departmental membership. These attributes were scrubbed from the dataset to protect individual anonymity before the data were made available for research. However, it seems unlikely that unobserved differences in geographic location could explain the variegated but theory-consistent pattern of homophilous interactions we observed.

Perhaps the most important limitation of our study is that it represents a single work organization. Unobserved characteristics of the organization, such as its culture, or the nature of its business, may have shaped the kinds of ties people in the organization developed on TamTamy. Future work is needed to help generalize beyond the idiosyncrasies of the single organization we examined.

CONCLUSION

There is growing recognition of the significance of Enterprise Social Media (ESM) for organizations. ESM offer a platform for social interactions that has been hailed as "unique and potentially transformational" because not only do ESM offer users a quick and efficient means to publish information and connect with others, they also afford the visibility and persistence of communicative action, making it possible for people to radically expand the range of people they connect with (Leonardi, Huysman, & Steinfield, 2013: 3). Indeed, much of what we take to be fundamental to organization and organizing, increasingly takes place in virtual social networks. Our study suggests that the same attentional processes that enhance the salience of some attributes over others and thereby shape who people attend to and connect with in traditional social networks will also shape who people attend to and connect with via enterprise social media. If organizations are to fully reap the potential of enterprise social media, they will have to anticipate and work around the same fundamental social psychological forces that have shaped traditional (offline) social networks in organizations.

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