You are who remembers you.

Detecting leadership through accuracy of recall

Abstract

We measured interpersonal perception accuracy by focusing on the relationship between actors' centrality and their ability to accurately report their social interactions. We used the network measures of actors' betweenness centrality and degree centrality to identify the most prominent members by correlating ego-perception and alter-perception in a "non-reciprocity" type of misalignment. We found a positive correlation between actors' centrality and their centrality as assessed by senior management, and a negative correlation between actors' centrality and their accuracy in recalling interactions. Underreporting social interactions may represent a third way of measuring the importance of members and finding the most influential actors.

1. Introduction

Social scientists have long been interested in understanding what makes some respondents more accurate than others in recalling and reporting a social network's structure. As Bernard et al. stated (1984), "People do not know, with any accuracy, those with whom they communicate". Other scholars questioned their conclusion by proposing alternate explanations for the ability of informants to recall interaction patterns (Romney and Weller, 1984). Recent and old experimental studies found that individuals do not judge themselves as accurately as they are judged by their friends (Kumbasar et al., 1994, Cogan et al., 1915).

A more recent study investigated how an individual's position in the formal and informal social structure of the organization, along with his or her personality traits, represents an important determinant of the variability in people's accuracy in identifying the social structure (Casciaro, 1998). The main variables used to operationalize the role of the stable pattern of social relationships influencing accuracy in reporting social network data were work status, the position in the organization's formal hierarchy, and actors' centrality in the organization's informal networks (Freeman et al., 1987).

This study aims to contribute to social network research on interpersonal perception accuracy by focusing on the relationship between an individual's centrality in an informal social network and his or her ability to accurately perceive communications and social interactions. We used the social network measures of actors' betweenness centrality and degree centrality to identify the most visible and prominent members and find a relationship between an

individual's centrality and his or her ability to accurately perceive how that network is structured.

2. Theoretical Background

Over the last century, the leadership concept has been studied and conceptualized on many dimensions including individual traits, leader behavior, role relations, follower perceptions, influence over others and on organizational culture (De Souza and Klein, 1995). Traditional theories of leadership, such as transformational, charismatic and visionary, have been criticized as they fail to address the dynamic components of emergent leadership, defined as a social process in which an individual exerts significant influence over other members without the vest of a formal authority (Schneider and Goktepe, 1983). Models of emergent or informal leadership have been considered to be a leadership substitute when a formal leader is absent or ineffective.

In the theoretical perspective that considers organizations as living systems, leadership is conceived as "collective self-leadership", as a process, a group quality distributed between individuals in light of different circumstances and competencies (Youngblood, 1997, Gronn, 2002).

Our theoretical framework is based on the formal model of distributed leadership that has been described by various leadership scholars as an emergent property of a network of interacting individuals. Leaders emerge based on who is available, who has information and who is trusted to be competent in a specific situation (Wheatley, 2006).

Ancona et al. (2007) describe leadership as a set of four capabilities: sensemaking, relating, visioning and inventing. No formal leader can excel in all of these components, while they must concentrate on how to work with others to compensate for their weaknesses. The authors state that "*The incomplete leader also knows that leadership exists throughout the organizational hierarchy – wherever expertise, vision, new ideas, and commitment are found*" (2007, p. 94). Empirical research suggests that informal leaders within small groups play a key role in developing the group's efficacy, being in a unique position to influence beliefs and expectations of group's members (Pescosolido, 2001, Smircich and Morgan, 1982).

Other empirical results indicate contrasting conclusions on the relation between power and network perception. Overbeck and Park (2002), for example, examined whether powerful people fail to identify the less powerful, and suggest that higher power actors have more accurate perceptions than lower power ones. Opposite results were found by other studies (Fiske and Depret, 1996), which propose that lower-power actors are more accurate, whereas other experiments found no connection between power and perception (Freeman et al., 1987).

Studies based on the constructural theory have proposed frameworks that describe various types of cognitive inconsistencies, such as the non-reciprocated relationships or the non-symmetric relationships, that try to reduce the linguistic confusion associated with these concepts (Carley and Krackhardt, 1996). In 2004 Wellman, White and Nazer analyzed the asymmetry in intercitation data using the variables "early cocitation" and "participation in conference" to predict the

misalignment of *in*citations and *out*citations. Casciaro et al. (1999) state: "*Accuracy in social network perception is broadly defined as the degree of similarity between an individual's perception of the structure of informal relationships in a given social context and the actual structure of those relationships*".

The relation between power and accuracy has been recently investigated by Simpson and Borch (2005) with an experimental test to explore the validity of two arguments that they call "power begets perception" and "dependence begets perception". The former suggests that the actors higher in power are more accurate in perceiving who is connected to whom than do those lower in power, by virtue of their network position. The latter state that low-power actors "will invest more cognitive resources in making the best of their disadvantaged situation" since they are dependent on higher power actors. As a consequence of this dependence, low-power actors may need to investigate more carefully who is tied to whom in order to make a better decision (Simpson and Borch, 2005, p.280). Simpson and Borch conclude that low power actors are more accurate in their perceptions of distal ties than high-power actors. The reason is that these people need to be more attuned to anything happening beyond their immediate adjacencies. This might suggest that actors in a less advantaged position can be more effective than their high-rank counterparts at changing their structural location and can either challenge or support the activity of high-rank actors.

This research is also based on leadership theories that conceptualize leader's reputation as directly emanating trust and accountability (Hall et al., 2004,

Bromley, 1993). As actors interact with others, a network of informal roles and related expectations, known as role-sets, are established. The social network to which an actor belongs can be a source of his/her reputation as leader or good performer (Kilduff and Krackhardt, 1994). Thus, as Hall et al. pointed out (2004, p.219) "*a leader's reputation is both a product of, and is defined by, social networks*". Based on this perspective, our research aims to explore new ways of recognizing emergent leaders by looking at the differences in perception of relevant ties.

3. Research Hypothesis

For the purpose of this research, we introduce an index of asymmetrical perception and an index of leadership to test the validity of the following hypothesis:

> *The lower the ratio between self-perception and alter-perception, the higher the probability for an actor to have leadership roles.*

The index of asymmetrical perception is based on the ratio between Self and Alter reported data. We introduce an S/A index defined as:

$$\frac{S}{A} = \frac{\sum_{i=0}^{n} \text{Interactions Self Reported}}{\sum_{i=0}^{n} \text{Interactions Reported by Alter}} \qquad (1)$$

The more S/A approximates 1, the more symmetry there is between what respondent reports and what alter reports. S/A values that are significantly over 1 indicate that actors reported a number of interactions higher than the number of interactions perceived by alters. S/A values that are significantly below 1 indicate an asymmetry due to alters' perception being higher than respondents' recall.

The ratio we used is similar to another index, the contribution index, which is a ratio defined as the number of messages sent and received by any actor in the network (Gloor, 2006)[1].

To obtain the Leadership Index, we multiply the average values of T (trust), P (prestige) and C (contribution) – defined in section 5 – for each individual by the indicators of actor betweenness centrality (BC):

$$\text{Leadership Index} = \text{ Average}(T, P, C) * BC \qquad \textbf{(2)}$$

We multiply the mean of (T, P, C) with BC, since BC is a proxy for the influence of an actor in the network, and therefore reinforces the "leadership" position of the actor. Degree centrality is already considered in the S/A index.

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[1] The contribution index is +1 if somebody only sends messages and does not receive any message. It is −1 if somebody only receives messages and never sends any. Finally, the contribution index is 0 if somebody has a totally balanced communication behavior where they are sending and receiving the same number of messages. In our study the S/A and CI indices are highly correlated (r=0.95).

4. Description of the Research Site

This study was conducted within a technically-oriented Italian graduate school of management that both educates students and does research projects. Through seven web surveys, we gathered data on the frequency of interaction among members of the school with reference to different communication channels: chat, face-to-face, phone. We used the term "complete network" to refer to the network made up of multiple sets of interactions among actors (i.e. different channels). Finally, we compared the social network data with a direct observation of the evolution of career paths of this group one year after the survey.

Our study population consisted of (1) a small leadership team of senior researchers who headed research projects and taught courses, of (2) researchers and technicians who worked on project teams, and (3) doctoral and masters degree students who completed coursework and also contributed to projects.

We monitored the communication patterns of 25 members who responded at least 5 of 7 times to the web surveys. The sample represented approximately 60% of the population including faculty members and project managers, PhD and Master's students, junior researchers, and programmers. It was composed of members involved in research activities who had approximately the same age and who were in a tutor/student relationship not based on formal hierarchies. At the time of the survey, the total membership was 44, but we removed the Director and the administration staff from the sample, since they did not directly collaborate with others on research projects. Being interested in seeing "who

interacts with whom every day for work related matters", we limited our population to 42 active members.

We identified three sub-communities: coordinators (16%), collaborators (16%), and contributors (68%). We chose these three categories as they represent the general task and reciprocal responsibility that each member had in the team: coordinators were formally in charge of managing resources; collaborators were at an intermediate level of responsibility and visibility; and contributors provided their specific knowledge to coordinators and collaborators.

5.   Data Collection Methods

Web surveys have been administered to obtain structured data on the number of times peers communicated with each other using different channels: chat, face-to-face and telephone. To parse communication data we used Condor (formerly called TeCFlow), a software suite that can collect and translate different types of data into information about the sender, recipient(s), and date/time of each message. With this data, Condor can then generate adjacency matrices and interactive movies of communication flows (Gloor et al., 2003).

In the web survey respondents were provided with a roster of all the people working in the organization. They were asked to report the number of times they communicated by phone, by chat and in-person with each listed colleague with reference to work-related issues. Respondents were asked to recall only interactions that occurred on the same day the survey was taken, to reduce errors

that can be associated with forgotten network ties[2] (Allen, 1984). Questionnaires were sent on different days of the week to avoid an over-representation of workdays that regularly have a high level of interaction.

Then, we conducted semi-structured interviews with three key actors - not part of our study population - to gain a better understanding of the meaning of relationships among respondents. We involved researchers in charge of project management and curricula design. Through these interviews actors' behavior was classified according to three indices[3]: their level of *trustworthiness* within the team (T), of *prestige* among peers (P) and their degree of *contribution* to the team performance (C). Specific questions investigated how much each actor "was considered trustworthy by peers" (T), "was admired by peers" (P), and "was providing high contribution to the performance of his/her team" (C). Finally, we directly observed this team after one year from the survey administration, to identify how and to what extent formal and informal roles had changed.

6. Network Data Analysis

Survey data was normalized according to actors' response rates (7,6,5 times): the number of time people communicated was multiplied by 1, 1.4 or 1.16, in order to obtain comparable data. The number of times actors reported interactions was multiplied on a 7-day basis:

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[2] Our decision to only ask respondents about interactions on the same day was based on the advice of Thomas J. Allen, who found that respondents become very unreliable in remembering interactions which are more than one day in the past (Allen & Raz, 2007).
[3] We used a Likert scale fro 1 to 5, where 1 meant "very low" and 5 "very high".

- Multiplied by 1 for those who replied 7 times (7/7=1)

- Multiplied by 1.4 for those who replied 5 times (7/5=1.4)

- Multiplied by 1.16 for those who replied 6 times (7/6=1.16)

The Condor tool was used to export survey data into non-directional, valued adjacency matrices, where the value corresponded to the total number of interactions that were reported to occur between two members of the community. We will refer to valued adjacency matrices having N=25 rows and N=25 columns, where N represents the 25 sample members. The matrix consists of sender-receiver intersections as we are working with asymmetric matrices. Row names are the respondents and column names are the receivers of the relations.

We asked each individual to report which colleague they communicated with and how often they did. The disagreement we found was of the form $R_{iji} \neq R_{jij}$. This means that actor i perceives (and reports) that self (i) has had a certain number of interactions with other (j), which is different from the number of interactions with i that other (j) perceives (and reports). Using the terminology introduced by Carley and Krackhardt (1996), the misalignment we found is of the type called "non-reciprocity", since actors involved in the same interaction (by chat, face-to-face or phone) perceive and attribute different values to the same interaction ($R_{iji} \neq R_{jij}$). For example $R_{iji} = 5$ times, as i recalls 5 interactions with j, but $R_{jij} = 2$ times as j recalls only 2 interactions with i.

In Table 1, the last row of the matrix shows the number of reported interactions according to others' perception. For instance, the cell

$A = (R_{jij}) + (R_{kik})$ A reports the values of the interaction between all the (N-1) actors and actor i. Thus, it shows what other people perceive (and report) about their interactions with i. The last column on the right of Table 1 reports the sum of the perceptions that respondents had about the same relationship with receivers and that are different from i. Thus, it indicates what actors self-perceive about the interaction with others (j, k, and so on).

Table 1. Valued adjacency matrix and sources of asymmetry.

In this paper, we try to identify the main reasons for the asymmetry based on non-reciprocated relationships ($R_{iji} \neq R_{jij}$). Accuracy of perception will also be operationalized by looking at differences in terms of self-perception and others' perception (values in the last row and in the last column of Table 1). By correlating what self and other recall, we tested symmetry by using an "internal measure of accuracy", that is the extent to which the subjective recall made by self corresponds to those made by others (Kashy and Kenny, 1990).

We built an adjacency matrix that reports in each cell the number of communication ties between respondents (listed in row) and receivers (listed in column) according to the entire set of face-to-face interactions, chat sessions and phone calls. For example, actor AM recalls 1 interaction with MD, while MD reports 4 interactions with AM. Each cell contains data normalized according to

the individual response rate. The column "self" reports the sum of interactions that self recalls towards alter. The column "alter" reports the values of the interactions as they are reported by other people.

Table 2. Adjacency matrix that reports the combination of face-to-face, phone and chat interactions.

7. Findings

7.1 Variation in accuracy and formal relationships

We analyzed non-reciprocal relationships by classifying actors on the basis of the nature of projects with which they were involved. Other studies operationalized the actors' work status by using the dichotomy "part-time vs. full-time" (Casciaro, 1998).

In this study, work status was operationalized and measured as follows: "coordinators" were given a score of 1; a score of 2 was given to "collaborators" and "contributors" were given a score of 3. Coordinators were formal leaders with high seniority in the organization, representing the operational tie between the school's Directors and the students/researchers. Collaborators were junior researchers involved in tutoring activities for younger members. Contributors were students, technicians and programmers who were asked to perform specific tasks within a single project. Assignment into one of the three categories for each actor was done in interviews with key respondents. In Figure1, VN, AZ, CP,

ANC are the project managers/coordinators. AM, EC, ML, ZM are collaborators and the others are contributors.

Figure 1. The S/A index calculated for each actor

Our findings indicate that the more an actor had a coordination role within a group, the lower was the S/A value, as shown in Figure 2. Coordinators under-reported the interactions occurred more than the collaborators and contributors did. The S/A index on average was 0.56 for coordinators, 1.3 for collaborators and 1.2 for contributors. This might suggest that the more actors have a formal role in coordinating resources, the more they under-estimate the frequency of interactions they had.

For example, a second-year PhD student involved in multiple projects, AM, was tutor of Master's students. Our results indicate that alters reported face-to-face, phone or chat interactions with AM a total of 75 times in 7 days, whereas AM reported only 19 ties with the 24 participants. AM is the second most central member in terms both of betweenness centrality (0.034) and degree centrality (24). AM was also considered reliable (trustworthy=3.75), admired by peers (prestige= 4), and a good team contributor (3.75). One year after the survey, we found that AM had been promoted from PhD student to the position of assistant professor.

These results highlight the gap in terms of self and alter's perceptions by indicating how tutors and students perceive the same relation in which they are

involved. The tutor-student relationship is emphasized by the S/A index, which is very low (0.065) compared to the average value of the entire sample (S/A=1.1).

A similar case is represented by CP, a project manager in charge of coordinating multiple projects (S/A index = 0.35). The same asymmetry is visible for the project manager ANC and the student/collaborator GT (S/A index = 0.57).

We found a positive correlation (r =0.49, p< 0.05) between actors' centrality and the reputation level assessed with reference to the three indicators (trust, prestige, and contribution). This can be interpreted in different ways. First, it could mean that the subjective perception given by management was a good approximation of the centrality of actors in the social network according to the frequency of interaction reported in the survey. Second, it might also imply that the more actors are trusted by upper management, the more they are provided with responsibilities, and this can increase the perception of peers looking at these actors as highly central.

We also found a negative correlation between the index S/A and the Leadership Index (correlation = -0.360, p=0.05). Although the sample size is small, this result might imply that the more actors are prominent in terms of informal leadership position, the more other people recall a higher number of interactions with them. These findings should be taken as a motivation for further research, to prove or disprove these hypotheses with a larger sample.

Table 3 shows the correlation coefficients between the S/A index expressing the degree of asymmetry, the actors' degree and betweenness centrality, as well

as the three indicators of trust, prestige and team contribution. We considered the degree and betweenness centrality with reference to the complete network.

Table 3. Correlation between indicators of centrality and asymmetry

We also observed a stronger negative correlation for coordinators and collaborators than for contributors. Although they are not statistically significant, these results have been reported to indicate possible future research to compare formal roles of actors and their accuracy of recall (see Table 4).

Table 4. Correlation between indicators of centrality and asymmetry by role

7.2 Variation in accuracy and informal relationships

It is interesting to note that a non-reciprocated relationship exists even when people do not have a formally-defined role of coordinator or collaborator. It seems that what is important is that their capabilities are recognized by peers in a process of emerging leadership within the community.

The asymmetry that we found with coordinators and tutors being recalled as frequent communicators despite their lack of precise recall can also be used to discover the emergence of informal or emergent leaders. As De Souza and Klein

showed (1995), the informal leader has a very strong effect on group goals and subsequently on group performance. Informal leaders are actors who engage in leadership activities, but whose right to do so has not been formally recognized by the organization or group. Schneier and Goktepe (1983) defined an informal leader as one who exerts influence on other group members. Informal leaders do not possess formal power, unlike the formally-appointed leaders who have a defined position from which to influence others. Indeed, if the informal leader fails to meet the group's expectations, he or she can be deposed and replaced easily by another. When emerging leaders are working towards the same vision and goals as the formal leaders, they can help managers and formal leaders by reducing their burdens. Discovering informal leaders helps to support them and to free those with formal management responsibility to focus on what are their unique competences. As suggested by Simpson and Borch (2005) it is also possible that managers use this type of information to locate those who could possibly challenge their authority.

Two doctorate students, PD and MD, illustrate the role of students with no formal power, but still very central within the social network. Whereas PD ranked first for betweenness centrality (BC=0.0403), second for degree centrality (DC=23) and with an S/A index of 0.25, MD had an average betweenness centrality (BC=0.0068) and the lowest value of S/A Index (0.2241). One year after the survey, they had been selected by the Director to be in charge of new research areas. What PD and MD had in common was also a high preference for

communication via chat and face-to-face rather than email (12 email exchanges in the entire observation period).

Another example is provided by a Master's student (VC) who was highly-regarded by peers (trustworthiness=4, prestige=4.25 and contribution level=4.25). This student was 8th of 25 people in terms of degree centrality (20) and betweenness centrality (0.021). The student recalled a number of interactions with others that was 3 times lower than what others recalled with him. Also in this case, formal recognition from upper management came immediately after the conclusion of the Master's Program, when VC ranked first in the selection for the PhD Program.

Focusing on e-mail, we noticed that actors reporting less communication with peers were mostly receivers of emails, rather than senders. Indeed, the rate sent/received was 20/80 for PD, 35/65 for MD and 30/70 for VC.

This evidence suggests that it might be possible to identify informal leaders and in general actors with a high level of reputation among peers by looking at the difference in perception as shown in the S/A index. It seems that the group dynamics within the Master's and PhD community were such that informal leaders emerged through active communication behavior. This hypothesis is supported by the collected data. Through monitoring the combined communication via chat, phone and face-to-face, we obtained an overview of the emergent informal social relationships that was much more informative than merely collecting information exchanged by mining e-mail. The ties we observed gave an idea about the informal, cooperative relationships that built a shared

vision around common objectives, reducing the importance of formal, transactional communication.

8. Conclusions and Future Agenda

By considering the effect of degree and betweenness centrality on accuracy in social network perception, we tried to understand how the centrality of actors in the complete network relates to their capability to report a balanced reciprocal communication behavior (S/A =1).

By exploring relations between pairs of actors, we have suggested a trend in terms of "tutor-student relationship" as an important factor determining the asymmetry of response.

In this study, we found a positive correlation between actors' centrality and their centrality as assessed by key actors and a negative correlation between actors' centrality and their accuracy in recalling interactions. By monitoring the degree of inaccuracy through the self/alter index it might be possible to predict the individual centrality and the reputation level, as well as to identify informal leaders. The asymmetries we found suggest that under- and over-reporting of social interactions may represent a third way of measuring the importance of members within a community and identifying the most influential ones. In summary, by monitoring the degree of inaccuracy using the S/A index it might be possible to predict individuals' centrality, assess reputation levels, and identify informal leaders. A construct such as informal leadership is extremely complex and is influenced by many factors. In this paper our focus is on the correlation of

variables like reputation and trust with network centrality to identify actors with informal leadership properties.

While the sample in our study is small, we believe that our results merit replication with a larger sample to assess the validity of using S/A and actors' centrality metrics to determine the presence of informal leadership. Although in this paper we focused on tutor/student relationships, we believe that our proposed method for detecting emerging leaders could be applied to various categories of knowledge communities (e.g. communities of practice).

A further research path might be to identify informal leaders and actors with high peer-reputation by observing the accuracy of recall with reference to different communication channels. We speculate that the imbalance in recall of communication might differ for various channels, and might even be dissimilar for different characteristics of informal leaders. Regardless, it seems that one is defined by how one is being remembered.

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Table/Figure
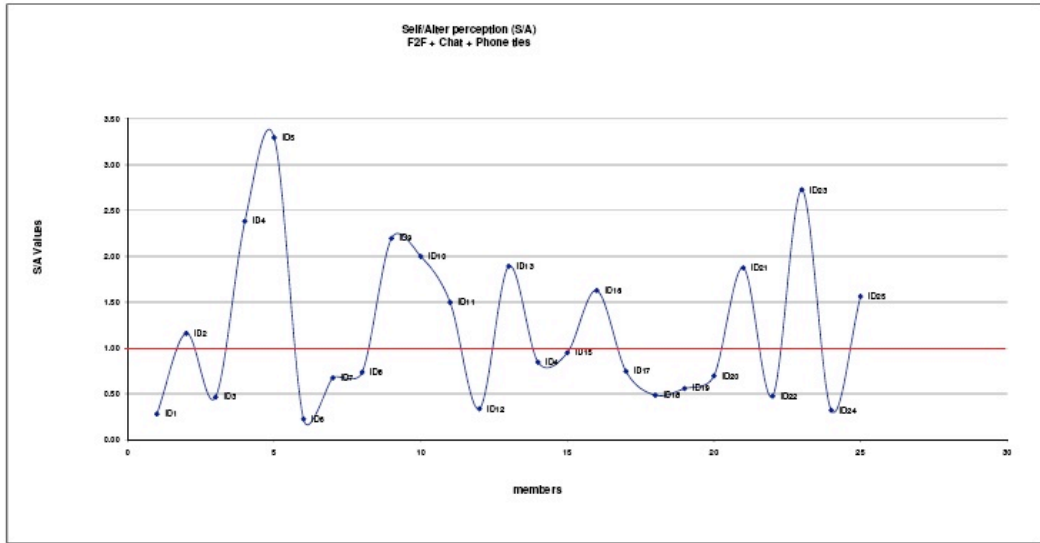
Figure 1: The S/A index calculated for each actor

		Alters			
		i	j	k	Σ Self Perception (S)
Self	i	/	R_{iji}	R_{iki}	S1=(R_{iji}) + (R_{iki})
	j	R_{jij}	/	R_{jkj}	S2=(R_{jij}) + (R_{jkj})
	k	R_{kik}	R_{kjk}	/	S3=(R_{kik}) + (R_{kjk})
	Σ Alter Perception (A)	A1=(R_{jij}) + (R_{kik})	A2=(R_{iji}) + (R_{kjk})	A3=(R_{iki}) + (R_{jkj})	

Table 1: Valued adjacency matrix and sources of asymmetry

	id1	id2	id3	id4	id5	id6	id7	id8	id9	id10	id11	id12	id13	id14	id15	id16	id17	id18	id19	id20	id21	id22	id23	id24	id25		Self	Alter
id1	0	0	0	0	0	1	2	0	0	0	1	0	0	3	0	0	0	1	0	0	3	8	0	0	0	id1	19	75
id2	0	0	0	28	0	0	0	0	3	0	0	0	35	0	10	15	8	0	7	34	0	1	0	0	0	id2	142	126
id3	0	0	0	2	1	4	1	2	0	2	3	4	0	8	0	1	0	0	0	2	0	0	2	0	0	id3	32	74
id4	1	42	9	0	0	0	0	0	3	0	0	0	4	1	15	10	16	9	15	11	0	4	1	2	0	id4	143	68
id5	9	0	4	1	0	52	69	74	2	84	69	74	0	5	0	55	0	0	0	0	0	3	0	0	0	id5	501	167
id6	4	0	1	0	0	0	1	0	0	0	4	22	0	7	0	10	0	0	0	0	1	2	0	0	0	id6	52	274
id7	6	0	1	0	16	4	0	31	0	13	3	23	0	0	0	20	0	0	0	0	0	5	0	0	0	id7	122	188
id8	4	0	7	0	20	7	29	0	0	14	7	37	0	0	0	6	0	0	0	0	0	2	0	0	0	id8	133	184
id9	2	0	0	0	3	21	0	0	0	0	0	15	0	9	0	8	0	6	0	0	0	11	1	0	0	id9	77	40
id10	7	0	13	0	52	25	34	45	0	0	26	27	0	0	0	30	0	0	0	0	0	5	0	0	0	id10	264	135
id11	21	0	10	0	38	78	6	0	0	0	0	49	0	1	0	32	0	0	0	0	0	1	0	0	0	id11	237	163
id12	5	0	6	0	0	25	10	10	0	0	19	0	0	7	0	5	0	0	0	0	1	0	0	0	1	id12	89	292
id13	0	39	0	6	0	0	0	0	0	0	0	0	0	0	12	2	4	1	6	9	0	0	0	8	0	id13	87	53
id14	3	0	6	0	1	4	0	0	14	0	4	4	0	0	0	1	0	0	0	0	0	11	0	0	0	id14	49	57
id15	0	15	0	8	1	0	1	0	0	0	0	0	9	0	0	1	1	1	1	2	0	0	0	0	0	id15	42	47
id16	6	18	15	9	33	53	34	21	0	21	25	36	5	5	7	0	0	0	1	2	0	0	0	9	0	id16	301	201
id17	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	3	0	0	0	10	6	id17	35	50
id18	1	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	id18	16	26
id19	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	10	0	0	27	0	1	0	0	0	id19	43	79
id20	0	12	1	1	0	0	0	0	1	0	0	0	0	0	0	0	3	1	40	0	0	2	0	1	2	id20	64	101
id21	5	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2	1	0	0	0	0	4	id21	15	8
id22	0	0	0	0	1	0	1	1	3	1	0	0	0	3	0	1	0	0	0	2	0	0	58	0	0	id22	73	205
id23	0	0	0	0	0	0	0	0	2	0	0	0	0	7	0	0	0	4	0	0	0	148	0	0	0	id23	161	64
id24	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	1	0	0	0	0	4	id24	11	37
id25	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	0	1	6	3	0	0	7	0	id25	25	17

Table 2: Adjacency matrix that reports the combination of face-to-face, phone and chat interactions

Correlations

		ASYMMETR	BC	DEGREE	TRUST	PRESTIGE	CONTRIBU
ASYMMETR (S/A)	Pearson Correlation	1	-,311	-,346	-,205	-,182	-,158
	Sig. (2-tailed)	,	,131	,090	,325	,385	,452
	N	25	25	25	25	25	25
BC	Pearson Correlation		1	,942**	,159	,402*	,277
	Sig. (2-tailed)		,	,000	,447	,047	,181
	N		25	25	25	25	25
DEGREE	Pearson Correlation			1	,371	,534**	,437*
	Sig. (2-tailed)			,	,068	,006	,029
	N			25	25	25	25
TRUST	Pearson Correlation				1	,619**	,817**
	Sig. (2-tailed)				,	,001	,000
	N				25	25	25
PRESTIGE	Pearson Correlation					1	,601**
	Sig. (2-tailed)					,	,001
	N					25	25
CONTRIBU	Pearson Correlation						1
	Sig. (2-tailed)						,
	N						25

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 3: Correlation between indicators of centrality and asymmetry

Asymmetry Coordinators	ASYMMETRY	BETWEENNESS	DEGREE C.	TRUST	PRESTIGE	CONTRIBUTION	ASSESSMENT
Pearson Correlation	1	- .245	-.267	-.180	-.180	-.137	-.180
Sig. (2-tailed)	.	- .328	.284	.476	.474	.588	.475
N	18	18	18	18	18	18	18
Asymmetry Coordinators & Collaborators	ASYMMETRY	BETWEENNESS	DEGREE C.	TRUST	PRESTIGE	CONTRIBUTION	ASSESSMENT
Pearson Correlation	1	-.404	-.520	-.282	-.240	-.235	-.286
Sig. (2-tailed)	.	.322	.187	.498	.567	.575	.492
N	8	8	8	8	8	8	8

Table 4: Correlation between indicators of centrality and asymmetry by role