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Learning to Trust: Networks Effects Through Time

Davide Barrera and Gerhard G. van de Bunt

This article investigates the effects of information originating from social networks on the development of interpersonal trust relations in the context of a dialysis department of a Dutch medium-sized hospital. Hypotheses on learning effects are developed from existing theories and tested using longitudinal data concerning the complete networks of trust and (informal) communication relations among employees observed at four different time points. The results support the existence of a learning mechanism operating both within dyads and through the social networks in which the dyads are embedded: actors learn to trust (or distrust) each other from their own past experience as well as from information that they receive from colleagues with whom they have regular communication.

Introduction

In many organizations, cooperation among colleagues is an essential prerequisite for the effective functioning and performance of the organization. Functioning as a 'lubricant' for cooperation (Arrow, 1974), trust can substitute more 'expensive' monitoring devices (Chiles and McMackin, 1996; Creed and Miles, 1996; Das and Teng, 1998). Interpersonal trust has thus received much attention in the field of organizational relations (Burt and Knez, 1995; Mayer *et al.*, 1995; McAlister, 1995; Kramer and Tyler, 1996; Rousseau *et al.*, 1998; Kramer, 1999; Burt, 2005; Bijlsma-Frankema and Costa, 2005).

Within organizations, dyadic relations of trust are typically embedded in a complex system of social relations with third parties (Granovetter, 1985). In fact, colleagues working in the same environment have frequent opportunities of contact ranging from formal meetings to informal gatherings such as during lunch breaks. This set of formal and informal contacts creates networks of relations whose importance for organizational performance [see Flap *et al.* (1998) for review] as well as for intra-organizational dynamics

[see Krackhardt and Brass (1994) for review] has been increasingly recognized. Particularly, informal conversations provide colleagues with opportunities to discuss personal issues as well as to gossip about other colleagues (Burt and Knez, 1995; Wittek and Wielers, 1998; Burt, 2005). Thus, the development of dyadic trust relations between colleagues could be affected by the network of informal conversations. In this article, we answer the following question: to what extent does the network of informal communication influence interpersonal trust relations among colleagues?

In spite of the conspicuous body of research on trust, there is no universally accepted definition of the concept. Trust is sometimes viewed as a psychological state (McAlister, 1995), as a choice behaviour (Dasgupta, 1988), or as a relational attribute possibly incorporating both aspects (Mayer *et al.*, 1995). Most of these definitions, but especially those that conceive trust as a choice behaviour, share one key element: the trustor's (Ego) decision is based on her assessment of the trustworthiness of the person to be trusted (Alter) (Gambetta, 1988; Coleman, 1990; Hardin, 2002).¹ In embedded settings, this assessment can be influenced

by the information about Alter that is available to Ego once she faces the trust problem.

The kind of information effects in which we are interested is typically associated with Coleman's conceptualization of network closure as social capital (Coleman, 1990, chapter 12; Burt, 2005, chapter 3). According to Coleman's argument, information circulates faster in denser networks. Thus, for every Ego-Alter pair, Ego's assessment of Alter's trustworthiness is facilitated by the amount of information that is available to Ego through third parties. This argument is consistent with both information diffusion models (e.g. Buskens and Yamaguchi, 1999) and network control models (e.g. Raub and Weesie, 1990).² However, empirical evidence on the effects of available information on interpersonal trust is scarce and mostly based on cross-sectional design, thus making the inference of causal mechanisms mainly speculative [notable exceptions are Wittek (2001) and Van de Bunt *et al.* (2005)].

A different type of evidence comes from experimental research [see, for instance, Barrera and Buskens (2008)], but this poses a problem of external validity, due to the artificiality of the situations in which the behaviour is observed. Therefore, our aim is to investigate the effects of information originating from informal social networks on interpersonal trust between colleagues, addressing the shortcomings of existing research in two ways. The use of longitudinally collected survey data of complete networks of co-workers allows us, first, to improve on external validity and, second, to make stronger claims on the causal relations observed.

The definition of a social network depends on the content of the relationship, which is being studied. If trust is defined at the dyadic level, every trust relation identifies a directed tie and the set of all trust relations among colleagues constitutes a social network. The set of informal communication relationships constitutes a second network. Since people who trust each other are likely to speak regularly with each other as well, we can expect a certain extent of overlap between these two social networks. Thus, it is plausible that the social network formed by co-workers who talk regularly to each other influences the network of trust relations, and vice versa, the existing network of trust relations partly determines the informal communication network. Ideally, the two types of effects should be addressed simultaneously. However, here, we will focus on changes in the trust network resulting from the exchange of information between the actors, neglecting potential effects of the trust network on the communication network.

We opted for this approach for three reasons. First, existing theories stress the role of social networks in shaping trust relations and not vice versa (Buskens, 2002; Burt, 2005). Second, focusing on the effects of the informal communication network on dyadic trust relations is not a severe limitation because descriptive analyses of our data (see section 'Personnel') show that the trust network changes significantly across time, while the network of informal communication is rather stable. Third, given the current state of the art, our data are too complex to be analysed using existing statistical methods designed to tackle this kind of reverse-causality issues. We refer to section 'Results' for more details of the statistical model we applied.

In the next section, we will summarize existing theories and present hypotheses. Subsequently, we will describe the data and the methods used and present our results. Finally, we will discuss our findings, address some methodological issues, and give suggestions for future research.

Theories and Hypotheses

Coleman (1990, chapter 5) describes a trust problem as an interaction between two actors (Ego and Alter) characterized by an incentive structure corresponding to the trust game (Dasgupta, 1988). However, here, we are studying trust relations between colleagues, and our data do not contain any information on actual behaviour in a real trust problem. Therefore, we need to adopt a less formal definition of trust, focusing on Ego's attitude towards Alter. We refer to a trust relation between Ego and Alter as a directed tie from Ego to Alter that can exist in three different states: Ego trusts Alter, Ego distrusts Alter, or Ego is neutral towards Alter. We state that Ego (dis)trusts Alter 'if she is (not) willing to confide personal information concerning both private and work-related information to Alter'. Furthermore, we assume that a trust relation is in a neutral state if 'Ego is neither willing nor unwilling to confide in Alter'. This state of neutrality represents the middle point on a hypothetical continuum between trust and distrust. Furthermore, since we have defined trust as a personal attitude held by Ego, we assume that Ego's attitude towards Alter depends on her assessment of Alter's trustworthiness (cf. Gambetta, 1988; Hardin, 2002). In this context, Alter's trustworthiness refers to his capability to handle Ego's confidential information with due care.

We safely assume that Ego and Alter as members of the same organization are not complete strangers. In such a case, trust problems are said to occur

in embedded settings (Granovetter, 1985). In embedded settings, Ego possesses or can easily obtain information about Alter's trustworthiness through third parties. In addition, if Ego is somehow related to Alter, directly or through third parties, she has the possibility to reward Alter if he honors her trust as well as to retaliate if he abuses her trust. Two types of embeddedness can be identified: *dyadic embeddedness* and *network embeddedness* (Buskens, 2002; Buskens and Raub, 2002). Dyadic embeddedness refers to situations in which a relation between Ego and Alter pre-exists the specific trust problem or to situations in which Ego and Alter are likely to be facing each other again after the specific trust problem occurred. Network embeddedness refers to situations in which there exist third parties who are connected to both Ego and Alter by means of a relationship, allowing third parties to provide Ego with information about Alter, as well as to receive information about Alter from Ego.

The extra information available to Ego in embedded settings produces two types of effects on Ego's trust decision: *learning* and *control* (Buskens, 2002; Buskens and Raub, 2002). Learning indicates that information about behaviour of Alter in the past reaches Ego through dyadic embeddedness, because Ego herself had previous interactions with Alter, or through network embeddedness, because Alter had previous interactions with a third party (referred to as Tertius, hereafter) who can inform Ego about Alter's behaviour. Control, on the other hand, refers to the possibility for Ego to sanction or reward Alter depending on his behaviour. The embedded nature of a trust relation provides Ego with sanction and reward opportunities through dyadic embeddedness, because Ego can punish (reward) Alter for abusing (honoring) trust by withholding (placing) trust in future interactions, and through network embeddedness, because Ego can affect Alter's reputation by informing third parties of his behaviour, so that third parties will sanction (reward) Alter in the future.

We concentrate on effects of learning through dyadic and network embeddedness. We present hypotheses based on a broad range of theories about network effects on trust and test them using data from a longitudinal complete network (see Van de Bunt, 1999). We focus on learning effects because control effects require information on the behaviour of Alter in interaction with Ego for all Ego-Alter pairs, or information on the length of the expected common future, but this information is hard to get in a work environment, if not even impossible. Moreover, experimental studies have shown that learning effects

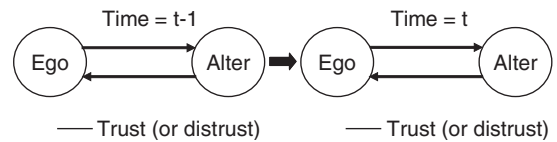


Figure 1 Dyadic embeddedness: trust (or distrust)

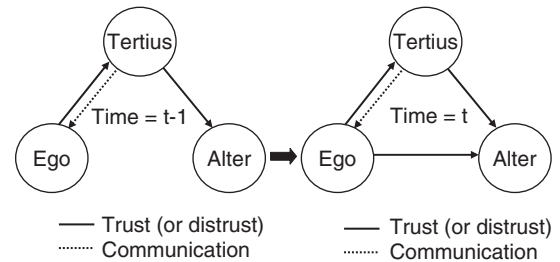


Figure 2 Network embeddedness: trust (or distrust)

are rather stable regardless of whether control effects are included in the analyses (Barrera, 2005).

We study a situation with three types of actors (see Figures 1 and 2), Ego, Alter, Tertius, and two types of (directed) ties: trust and informal communication. We represent actors with circles and directed relations with arrows. Dotted lines indicate a relation of informal communication; straight lines indicate a relation of trust (or distrust). A straight arrow from Ego to Alter indicates the trust relation from Ego to Alter. The state of this relation at time t is our dependent variable. As Ego assesses Alter's trustworthiness on the basis of the information available to her, the state of the trust relation from Ego to Alter depends on information originating from dyadic and network embeddedness.

Since we are investigating learning effects, we focus on information about the past. Therefore, dyadic embeddedness refers to previously existing relationships between Ego and Alter. If the dependent variable is measured at time t , dyadic embeddedness is represented by the two arrows connecting Ego and Alter at time $t - 1$. These indicate the extent to which Ego trusted Alter at time $t - 1$ and the extent to which Alter trusted Ego at time $t - 1$. In addition, we assume that these two relations capture the past of the relation between these two actors and that a trusting relation indicates a positive past, whereas a distrust relation indicates a negative past. For example, Ego trusting Alter at time $t - 1$ implies that, as far as Ego is informed, Alter has not abused trust before. We expect Ego's trusting choice towards Alter at time t to be

affected by her own attitude toward Alter at time $t-1$, as well as by Alter's attitude towards Ego at time $t-1$. That is, a trusting relation is more (less) likely after positive (negative) past. The hypothesized influence of Alter's past attitude toward Ego on Ego's present attitude towards Alter is consistent also with a preference for reciprocal relations found in numerous longitudinal network studies. Therefore, we refer to this effect as a *reciprocity effect*. This results in two hypotheses on effects of learning through dyadic embeddedness:

H1 The more Ego trusted Alter in the past, the more Ego trusts Alter in the present.

H2 The more Alter trusted Ego in the past, the more Ego trusts Alter in the present.

Hypothesis 1 may seem to be stating the obvious, but it needs to be included for three reasons. First, this hypothesis is consistent with existing learning models (e.g. Buskens and Yamaguchi, 1999). Second, empirical research on trust in embedded settings shows that the effects of dyadic learning typically outweigh those of network learning (Barrera and Buskens, 2008). Third, it is necessary to control for dyadic learning in order to avoid overestimating the network learning effects.

Turning to the effects of network embeddedness, in Figure 2, the dotted line connecting Tertius to Ego indicates the frequency at which Tertius talks to Ego. The straight line connecting Tertius to Alter and Ego to Tertius indicate the extent to which Tertius trusts Alter and Ego trusts Tertius, respectively. Consistent with information-diffusion type of models, the information about Alter that Ego receives from network embeddedness depends on the number of third parties who talk regularly to Ego and on what these third parties can tell Ego about Alter. Furthermore, considering that there might be differences in the importance that Ego attaches to information released by different third parties, we maintain that information originating from third parties is more important for Ego if she trusts these third parties and less if she does not trust them.

Concerning the content of informal conversations regularly occurring between Ego and third parties, we assume that if third parties talk very often with Ego, it is also likely that, during these conversations, they will disclose the information they have about Alter's trustworthiness and that third parties who trust Alter release *positive* information about him, whereas third parties who distrust Alter release *negative* information about him. The latter assumption is particularly relevant because there is some empirical evidence for types of effects of third-party information on interpersonal trust that differ from what we hypothesize

here. Studying the same problem using ego-centered network data of managers, Burt argued that, due to etiquette regulating informal conversation among colleagues, information about Alter disclosed to Ego by third parties is selected so that it only confirms Ego's previous beliefs about Alter, without bringing any new insight (Burt, 2005, p. 171 and *passim*). In other words, Burt claims that third parties' true trusting attitude toward Alter is never communicated to Ego, unless Ego and third parties already have the same opinion about Alter. Burt referred to this effect as *echo*. By contrast, the effect that we postulate in our next two hypotheses corresponds to his alternative mechanism, called *bandwidth* (Burt, 2005, p. 169 ff). However, Burt's evidence comes from cross-sectional survey data, which do not allow observing network changes. Therefore, the hypothesized mechanisms are not explicitly tested. Moreover, most of the effects reported are actually compatible both with echo and bandwidth.

Summarizing, we maintain that Ego's decision whether to trust Alter will be *positively* influenced by the number of third parties holding a trusting relation towards Alter who talk regularly to Ego and are trusted by her. Conversely, Ego's decision whether to trust Alter will be *negatively* influenced by the number of third parties holding a distrusting relation towards Alter who talk regularly to Ego and are trusted by Ego. Hence, we posit the two following hypotheses:

H3 The more information Ego received from third parties who trust Alter, the more Ego trusts Alter.

H4 The more information Ego received from third parties who distrust Alter, the more Ego distrusts Alter.

In addition, we expect the effect of negative information to be stronger than the effect of positive information, because trustworthiness could be simulated. In a world where all trusting opinions are formed according to third-party second-hand information and where everybody *knows* that all trusting opinions are formed according to third-party second-hand information, an untrustworthy actor has an incentive to fake trustworthiness in order to build a positive reputation and then abuse trust at a later time. Therefore, if third parties report to Ego that they trust Alter, this information only implies that Alter has been trustworthy so far. However, if third parties report to Ego that they do not trust Alter, this information could imply that Alter already abused trust with them in the past. Thus, Ego should take negative information into greater consideration than positive information. This hypothesis is consistent with game-theoretical arguments about repeated games with

incomplete information (Kreps and Wilson, 1982). Therefore, we formulate the following hypothesis:

H5 Information stemming from third parties distrusting Alter has a stronger effect on Ego's trusting decision vis-à-vis Alter than information stemming from third parties trusting Alter.

Data

Longitudinal network data were collected in a dialysis department of a Dutch hospital. The collection of quantitative data was preceded by 3 months of participant observation. During this period, one of the researchers worked and lived in the hospital. He had the status of a student on work placement and was dressed in the formal hospital outfit. This observation period was important for the success of the research in many ways (see Van de Bunt, 1997). First and most important, it created a situation of mutual trust between the employees and the researcher. Second, the observation period permitted to understand work processes and decision-making procedures in the department. Third, it served to retrieve useful information (e.g. about the history of the department) to optimize the design of the questionnaire. The first two objectives were obtained by means of observation and informal talks, the latter with interviews with key figures in the department.

Following the observation period, data were collected once every 4 months for a period of 1 year. The respondents were allowed to fill in the questionnaire at home. During data collection, the respondents were offered the possibility to contact telephonically the researcher in case they needed help with some of the questions. More information can be found in Van de Bunt (1999). Below, we describe relevant parts for the present project.

Historical Background

The description of the history of the dialysis department is based on in-depth interviews with persons occupying various functions (i.e. nursing and technical staff, the head of the department, and a nephrologist).

On the basis of these interviews, the department can be described as troublesome and rather hierarchically organized. Through the years, there have been several disputes between personnel with different specialties (nursing versus dialysing), between personnel favouring different dialysing methods, between personnel with different ideas about leadership (task-oriented versus people-oriented), and between personnel with different levels of ambition. Most of these quarrels still

persisted during the data collection period. The former head of the department, a people manager, was replaced by the hospital management by a strictly professional manager (almost 2 years before the data were collected). The new manager did not want to listen to those who, in her paraphrased words, 'thought of work as a way to pass the day', but instead listened to and favoured the ambitious and relatively highly educated staff. This attitude stimulated mutual hostility among employees with different characteristics. The climate at the department somewhat improved during the observation period, but there were still many people gossiping about each other and not trusting each other.

Personnel

Normally, the dialysis nurses are so-called A-nurses with a degree in dialysis. However, because of the shortage of personnel, some people had been hired without the necessary qualification. Some of them still worked there during the observation period. On the other hand, the number of new employees who had attended higher vocational training was increasing. This difference was another source of friction (those who had more working experience versus those who had more formal training). Approximately, twice a year, a new group of about three dialysis students (holding a general degree) entered the department. After successful completion of a 1-year training period, they were usually offered a tenure position. During that year, they were supervised by one of the dialysis nurses. Their supervisor was also the first person with whom the students spoke about the ins and outs of the department and consequently its history. Therefore, this relationship was very important. It influenced the students' view on the department and colleagues, as well as their tendency to trust some colleagues and not others. Consequently, depending on who was the appointed supervisor, a student might get a certain image of the department.

Normally, lunch breaks were taken in the hospital cafeteria, but because of the safety of the patients, dialysis nurses were not allowed to do so. They had lunch in their own department. By contrast, the non-nursing staff was allowed to take their breaks in the official hospital cafeteria, but hardly anybody did. The preliminary observation period showed that informal communication took place during these lunches, sometimes in the smoking area, and during work within the dialysis rooms. Most communication in the latter, however, was work-related, because it is generally difficult to discuss personal matters

Table 1 Personnel of the dialysis department (changes in parentheses)

	Time 1	Time 2	Time 3	Time 4
Dialysis nurses ^a	21	20 ₍₋₁₎	22 ₍₊₂₎	25 ₍₊₃₎
Students	8	11 ₍₊₃₎	10 ₍₋₃₊₂₎	7 ₍₋₃₎
Supporting staff ^b	8	8	8	8
Secretary	2	1 ₍₋₁₎	2 ₍₊₁₎	2
Total	39	40	42	42

^aIncluding: nurses, the head of the department and two team leaders.

^bIncluding: laborants (2), social workers (2), technicians (3), and kitchen (1).

or gossip about colleagues, while looking after the patients.

At the start of the project, the employees had worked at the dialysis department on average for almost 8 years. This seems long, but a few members raise the average. More importantly, a relatively large part (33%) had worked less than one and a half year at the department. All members were between 25 and 57 years old. Almost two-thirds of the staff, mostly dialysis nurses, had irregular working hours, whereas the rest (including some nurses) had regular working hours from nine to five. Almost one-third of all employees attended higher vocational school, and finally, 80 per cent of all employees were female. Table 1 shows the number of persons that were employed during the data collection period. The response rate was approximately 90 per cent.

Since the nursing staff worked in largely overlapping, but irregular shifts, every morning handing over the relevant patient information was crucial. This was done by means of written instructions. During the rest of the day the handing over was done orally. These day-to-day routines can easily go wrong because of ill handwritings, imprecise instructions, lack of time to discuss the handing over, etc.

The dialysis department held very many formal gatherings, organized at regular time intervals, such as staff meetings, work consultations, team consultations, and patient consultations. Some of them were strictly organized, but some were rather chaotic, did not have standard procedures, and produced quite some friction. For example, work consultations—held once every 3 weeks—were restricted to the nursing staff, and much disorganized. In theory, they were allowed to make decisions, but hardly anyone knew the procedures. The minutes were made by volunteers, mostly badly written and not to the point. Attendance to these meetings was not compulsory. Thus, the composition changed at every meeting. Consequently,

the atmosphere, the topics, and the solutions discussed were often radically different every time. Moreover, the meetings were used by some to gossip about absent colleagues.

The way the meetings were (dis)organized, the frequent hostility between (groups of) persons, and the large number of (potential) sources of frictions in the department made it difficult to trust each other. Nevertheless, in such a context, the importance of providing each other with reliable information regarding patients is tremendous; peoples' lives depend on it. Mutual trust is therefore crucial, but at the same hard to reach. This makes it necessary to understand how trust is built and how getting information from third parties may influence this process.

Measurements and Operationalizations

Our analyses are based on the answers to the following question about trust:³ 'We all feel closer to particular people than to others. By "close" we mean how much you confide in somebody. For example, whom do you confide personal information. This can include both private and work-related issues. Please indicate, for each of the persons on the following list, which of these five descriptions of your relationship to this person fits best'. These are unknown, distrustful, neutral, trustful, and very trustful; they were recoded so that a trustful or very trustful relationship takes value one, a neutral relationship takes value zero, and a distrustful relationship takes value minus one. For the informal communication network, the following question was used: 'During the past three months, how frequently did you talk, during working time, to your colleagues? It doesn't matter what you were talking about, but the conversation should have been more than the transmission of a simple message or a greeting'. This question had six answering categories ranging from 'never' to 'several times a day'.

The dependent variable is the trust tie from actor i to actor j at time t : y_{ij}^t . Both variables concerning learning effects from dyadic embeddedness (hypotheses 1 and 2) have been constructed by taking the value of the specific trust relation at the previous observation point. Thus, we take the value of the trust relation from i to j at time $t - 1$, y_{ij}^{t-1} as operationalization of i 's own past and we use the trust relation from j to i at time $t - 1$, y_{ji}^{t-1} to operationalize reciprocity.

The variables concerning effects of information from third parties are constructed as follows. Assuming that third parties trusting Alter release positive information about him to Ego, while third parties distrusting Alter release negative information about him to Ego,

the amount of positive information about Alter that Ego receives depends on the number of third parties holding a positive trust relation with Alter and talking regularly to Ego. Thus, we constructed the variable operationalizing positive third-party information about Alter as follows:

$$\ln \sum_{k=1}^n p_{kj}^{t-1} x_{ki}^{t-1} (y_{ik}^{t-1} + 1); k \neq i; k \neq j,$$

where x_{ki}^{t-1} is the frequency at which k talks to i measured at time $t-1$, and y_{ik}^{t-1} is the extent to which i trusts k at time $t-1$ and $p_{kj}^{t-1} = 1$ if $y_{kj}^{t-1} > 0$, and 0 otherwise; y_{kj}^{t-1} is the trust relation between actor k and actor j , the extent to which k trusts j at time $t-1$. Conversely, negative information is computed using the same formula, but with $p_{kj}^{t-1} = 1$ if $y_{kj}^{t-1} < 0$, and 0 otherwise.⁴ Suppose, i is Ego, j is Alter, and k is Tertius, the measures of the two relations x_{ki}^{t-1} and y_{ik}^{t-1} indicate the frequency at which Tertius talks to Ego and the amount of trust Tertius puts in Alter, respectively. In congruence with our hypothesis, this makes the two measures essential for the construction of a variable operationalizing the amount of information about Alter that is available to Ego. The third term, $y_{ik} + 1$, has been added in order to weight third-party information by how much Ego trusts the specific third party releasing the information. We weighted third-party information by $y_{ik} + 1$ rather than simply by y_{ik} , because the latter would imply that positive information becomes negative, and vice versa, if Ego does not trust the informant. Conversely, weighting third-party information by $y_{ik} + 1$ seems more realistic as it implies that this information is highly valuable to Ego if she trusts Tertius ($y_{ik} = 1$), somewhat less valuable if Ego is neutral toward Tertius ($y_{ik} = 0$), and it will be disregarded if Ego does not trust Tertius ($y_{ik} = -1$). Furthermore, we took the natural logarithm of this sum to account for the fact that an additional unit of positive (negative) information should have a diminishing effect on Ego's opinion about Alter if Ego already has much positive (negative) information about him.

Finally, we included several control variables and we controlled for homophily effects. Homophily effects were included as they are typically important predictors for the formation of close ties [see McPherson *et al.* (2001) for a review]. Here, we controlled for homophily effects concerning *age* and *function*. For age, we constructed a dummy variable taking value 1 when the difference between the age of Ego and Alter is smaller than 5, in absolute value. Since the personnel of the department can be straightforwardly classified in

'nursing' and 'non-nursing', function homophily is represented by a dummy variable taking value 1 for dyads belonging to the same group.

We also controlled for effects of sex and type of hierarchical relation between Ego and Alter. We looked at gender effects comparing men and women in terms of who trusts more and who is more trusted. We did this by including in the analyses two dummies, one taking value 1 when Ego is a man, the other taking value 1 when Alter is a man. Hierarchical position in the organization held by both Ego and Alter was included in the analysis, because the formal structure of an organization has been found to influence the pattern of informal relations (e.g. Lazega and Van Duijn, 1997). Therefore, we included two dummies, one taking value 1 when Ego occupies a higher position than Alter, the other taking value 1 when Alter occupies a higher position than Ego. For both variables, the reference category refers to the situation in which Ego and Alter occupy the same position in the hierarchy of the organization.

Descriptive Analyses

Before presenting tests of our hypotheses, we provide a short description of the network data. Table 2, where frequencies of trust and communication ties at the four measurement points are displayed, shows that there is considerable variation in the dependent variable.

As anticipated in the section 'Historical background', the number of negative ties in the trust network is relatively high: between 20 and 30 per cent of the total at all time points. This indicates that the data contain enough variation in the dependent variable to observe effects of both positive and negative information on trust relationships. Furthermore, the composition of the network changed during data collection as some employees left the department and some others joined (see Table 1). Consequently, newcomers could learn about the veterans and vice versa. Table 2 also shows the distribution of the informal communication network variable.

Examining the changes in the networks between two subsequent time points, Table 3 displays the number of ties changing and remaining constant in the trust and in the communication networks in all three time intervals. About a third of the trust ties change value between all time points. This indicates that the network of trust relations is changing significantly over time. Consequently, we should have enough statistical power to estimate the effects of information.

Table 2 Trust network and informal communication network: frequencies

	Time 1		Time 2		Time 3		Time 4	
	N	%	N	%	N	%	N	%
Trust network								
Distrust	321	29.3	278	22.6	293	20.8	245	16.9
Neutral	508	46.4	558	45.3	727	51.6	723	49.8
Trust	265	24.2	395	32.1	389	27.6	484	33.3
Total	1,094	100	1,231	100	1,409	100	1,452	100
Communication network								
Never	59	5.1	76	5.9	73	5.1	44	3
Less than once a month	316	27.4	192	14.8	285	19.8	232	15.7
1–3 times a month	418	36.2	497	38.4	533	37	603	40.8
1–3 times a week	317	27.5	465	35.9	476	33	507	34.3
Daily	43	3.7	65	5	75	5.2	93	6.3
Total	1,153	100	1,295	100	1,442	100	1,479	100

Table 3 Changes in the trust network and informal communication network: frequencies

	From Time 1 to 2		From Time 2 to 3		From Time 3 to 4	
	N	%	N	%	N	%
Trust network						
Constant	660	65.7	755	67	919	65.7
Changed	345	34.3	373	33	480	34.3
Total	1,005	100	1,128	100	1,399	100
Communication network						
Constant	519	47.8	573	48.3	774	53.8
Changed	566	52.2	614	51.7	665	46.2
Total	1,085	100	1,187	100	1,439	100
Change > 1	98	9	89	7.5	90	6.2

Looking at the communication network, more than 50 per cent of these ties change in all three time intervals between subsequent measurements. However, most of the changes consist of small oscillations, as illustrated by the last row of Table 3 displaying the frequencies of changes larger than one unit in the network of informal communication. Changes larger than one are only 9, 7.5, and 6.2 per cent of the total number of changes occurring in the three time intervals, respectively. Moreover, the average standard deviation of the values of every communication tie between the four time points is equal to only 0.53. Therefore, we can conclude that the communication network is rather stable. This result is as expected, because most interactions are work related (see section ‘Personnel’). As a result of this, even the effect of new persons

entering the department on the average frequency of communication is relatively small.

As argued in the introduction, this indicates that neglecting the effects of the trust network on the communication network is not a severe limitation for our analyses. Conversely, estimating the effects of interpersonal communication on trust relations is not problematic, because, while the structure of the communication network is relatively constant, the content of the information that the actors transmit to each other depends on their trust relations and the trust relations are changing over time.

Results

The unit of analysis consists of a directed dyad. Thus, observations have multiple levels of interdependencies.

Observations are (non-hierarchically) clustered within Ego, within Alter, within time points, and within dyads. In order to take these interdependencies into account, we used a multilevel Social Relations Model (Snijders and Kenny, 1999; Van Duijn *et al.*, 1999) including multiple observations of directed dyads over time to predict the trust network at time t , given the state of the networks at time $t - 1$. This model has been developed to analyse relational data measured at the dyadic level. In directed dyadic data, like ours, the relation from Ego to Alter and the relation from Alter to Ego are two different measures. That is, the trust relation from Ego to Alter is a measure of how much Ego trusts Alter, reported by Ego, while the relation from Alter to Ego is a measure of how much Alter trusts Ego, reported by Alter. A specific value on the trust relation from Ego to Alter could be affected by characteristics of Ego, such as her propensity to trust others, in general. It could also be affected by characteristics of Alter, such as his general trustworthiness. It could be affected as well by relational-specific features; Ego might trust a particular Alter, or Ego and Alter could know and trust each other before they became colleagues. Moreover, since we have four subsequent measures for every relation, we have to extend the original model by Snijders and Kenny (1999) to take into account the dependence of observations of the same dyads over time.

Summarizing, the data imply a complicated multi-level model in which observations are nested through time within directed dyads. Then, directed dyads are pair-wise nested in undirected dyads. In addition to this, directed dyads are non-hierarchically nested within Egos as well as Alters. Our model includes most of the random effects that are implied by this structure and is specified as follows:

$$y_{ijt} = \mu_t + \beta Z_{t-1} + \gamma X_{ij} + E_i + R_{(ij)} + D_{ij} + v_{ijt},$$

where y_{ijt} is the dependent variable, the trust relation from i to j observed at time t . In order to control for unmeasured variations due to the specific time in which the observation took place, we included fixed effects for time, μ_t . Therefore, this model has effectively three different constant terms, one for each measurement time. Z_{t-1} stands for the independent variables built using observations measured at time $t-1$. X_{ij} represents all time-constant covariates depending on i or j . E_i is the random effect for the error at the Ego level. $R_{(ij)}$ is the error at the dyad level (taking care of the interdependence between the two directed dyads ij and ji). D_{ij} is the error at the level of the (directed) dyad ij and v_{ijt} is the residual at the observation level. The inclusion of a random effect at

the level of Alter, or the possibility that residuals differ between time points, did not lead to different substantive results. Therefore, we choose to present the simpler model specified above.

As we do not have any information about the trust and information networks in the period before our first observation, we do not have measurements of the lagged variables Z_{t-1} for the first time point. Therefore, we estimate change in trust relations only in the second, third, and fourth observations as a function of information available to the actors at the first, second and third time point, respectively. However, observations concerning trust relations at the first time point are included in the independent variables, as part of the information about the past available to the actors at the second time point. The data are organized in dyadic format and missing data are computed listwise. The number of actors included in the analyses presented below is 40. However, the number of observations is not equal to $n(n-1)$ per every time point due to missing values. However, as our response rate was relatively high (about 90 per cent), our analyses explain trust dynamics in the department with sufficient accuracy.

The results of the multilevel Social Relation Models are shown in Table 4 where three different models are presented. Model 1 is presented as a benchmark, including only the fixed effects for time. Model 2 contains only control variables. In model 3, four variables referring to hypotheses 1–4 are added.

Looking at the maximum likelihood, we can see that it improves significantly from model 1 to model 3. However, the difference in the maximum likelihood is particularly large when comparing models 1 and 2 with model 3. This indicates that models including only fixed effects for time (model 1) and time-constant characteristics of the actors (model 2) fit the data less well than a model including also time-varying network variables (models 3). In model 1, the fixed effects for time indicate that, on average, there is more trust at the fourth time point. The random effects in model 1 show that there is considerable unexplained variance at all levels. The value of the residual v_{ijt} increases in models including effects of the main explanatory variables, while the random effects related to dyads are estimated at zero. This probably indicates that the additional independent variables included in model 3, such as *own past* and *reciprocity*, explain mainly variance at the level of the dyads and that, due to the reduction in unexplained variance at the dyadic level, the estimation process has difficulties in disentangling random effects at the dyadic level from the residual at the observation level.

Table 4 Random effects regression models

Independent variables (Hyp. ^a)	Dependent variable: Ego's trust in Alter Exp. sign	Coefficient (standard error)		
		Model 1	Model 2	Model 3
Constant (time 2)		0.121 (0.053)**	0.241 (0.060)**	0.522 (0.078)**
Constant (time 3)		0.097 (0.052)	0.216 (0.060)**	0.393 (0.081)**
Constant (time 4)		0.183 (0.052)**	0.304 (0.060)**	0.513 (0.080)**
Own past (H1)	+			0.457 (0.016)**
Reciprocity (H2)	+			0.150 (0.014)**
Positive information from third parties (H3)	+			0.028 (0.014)*
Negative information from third parties (H4)	-			-0.144 (0.014)**
Control variables				
Ego is a man			-0.147 (0.111)	-0.078 (0.078)
Alter is a man			0.027 (0.039)	0.070 (0.024)**
Ego is higher			-0.174 (0.045)**	-0.067 (0.027)*
Alter is higher			0.064 (0.048)	0.021 (0.029)
Same age			0.027 (0.045)	0.013 (0.022)
Same function			0.216 (0.041)**	0.047 (0.023)*
Model statistics				
Random effect at the Ego level		0.089 (0.022)	0.069 (0.017)	0.034 (0.008)
Random effect at the undirected dyad level		0.174 (0.014)	0.159 (0.014)	0.000 (0.000)
Random effect at the directed dyad level		0.068 (0.009)	0.069 (0.009)	0.000 (0.000)
Random effect at the observation level		0.195 (0.006)	0.195 (0.006)	0.269 (0.007)
Number of observations		3,266	3,266	3,266
Number of subjects		40	40	40
Maximum likelihood		5673.72	5624.15	5058.48

^aHypothesis 5 concerns the difference between the effects of positive and negative information from third parties.

*, ** Indicate two-sided significance levels of $P < 0.05$, $P < 0.01$, respectively.

In model 3, the main effects concerning learning through dyadic embeddedness (own past and reciprocity), as well as network embeddedness (positive and negative information), are significant in the expected direction. Dyadic embeddedness has a positive effect, indicating that Ego's trusting attitude versus Alter in the present is strongly influenced by positive experience, as captured by both Ego's trust in Alter in the past and Alter's trust in Ego in the past. Positive information about Alter has a positive effect on Ego's trust in Alter and negative information has a negative effect. Thus, hypotheses 1 through 4 are supported. Hypothesis 5 on the difference between the effect of positive and negative information is also supported: given the size of the two coefficients and relative standard errors in model 3 the effect of negative information is significantly larger than the effect of positive information.

Turning to the control variables, few have a significant effect on trust. Moreover, these results are rather unstable across models, which is not a strange result given the small size of our population. Only the effects of hierarchical relations and function homophily

are significant both in models 2 and 3. Ego is less likely to trust Alter when Ego occupies a higher position than Alter in the formal hierarchy, and more likely to trust Alter when either both are nurses or both are not nurses. The only other significant effect is gender: men seem to be slightly more trusted than women (but only in model 3). All other control variables are not significant in any of the models.

Discussion and Conclusion

In this article, we study the effects of information circulating in a network on the evolution of interpersonal trust relations among members of the network. The network consists of employees of a dialysis department of a Dutch hospital. The data consist of four measurements of the complete networks of interpersonal trust and informal communication at work, taken every 3 months during 1 year. Our results strongly support the view that interpersonal trust in social networks develops by means of a learning mechanism (e.g. Gulati, 1995; Barrera, 2007; Barrera and Buskens, 2008). However, unlike previous studies,

this paper provides evidence of learning effects in an intra-organizational setting using longitudinal complete network data.

Using two network variables, we constructed, for every node (Ego), an individual measure of both positive and negative information about every other node (Alter), which is available to Ego through third parties at every time point. Then, we used the measures at a given time point to predict interpersonal trust from any Ego to any Alter at the subsequent time point. The hypotheses are based on learning models through dyadic and network embeddedness. Results show that both types are important. Actors learn to trust from their own past experiences and prefer to reciprocate pre-existing relations. Positive information about Alter, available to Ego in the past, makes Ego's trust in Alter in the present more likely, while negative information about Alter, available to Ego in the past, makes Ego's trust in Alter in the present less likely.

Given that this result is found in a quarrelsome atmosphere, the management of the dialysis department should be wary of escalation of distrust. New people are entering the department on a regular basis while some of those who are dissatisfied with the management still occupy relevant positions in terms of the supervision of new students. Thus, the management has to deal with the influence process due to which people make others trust or distrust colleagues, as this process might ultimately lead to a decrease in cooperation between different subgroups. Luckily for the management, the new students are increasingly highly educated and not so easily impressed by the sitting staff anymore. It is a matter of years before the young, educated, and ambitious staff outnumber the veterans, as some will retire or leave, for instance, because of developments in ICT. In this respect, a good sign for the management is that, during the observation period, the average degree of intrinsic job satisfaction increased (Van de Bunt, 1999). Given our results, the management could develop a policy for the appointment of nurses to the supervision of students, aiming at reducing the spread of distrust.

Some issues concerning our analyses merit discussion. First, the communication network variable consists of communication at work between all employees, measured at four time points. However, concerning the content of this informal communication, we only know that it should be 'more than the transmission of a simple message or a greeting' as indicated in the question. Thus, our results are based on the assumption that colleagues talking more often with each other at work are more likely to release information about whom of the other colleagues they

trust and whom they do not trust. Furthermore, it is assumed that Ego considers more seriously information received from people she trusts herself. This assumption contradicts Burt (2005), who argues that, due to etiquette, informal conversations among colleagues only produce a reinforcement of pre-existing beliefs (i.e. echo) without providing any information from which actors could learn about others (i.e. bandwidth). Nevertheless, our results are consistent with bandwidth and not with echo. Compared to Burt's analysis, our conclusions are based on analyses of a relatively small network. This difference is important, because our network members are colleagues working in the same department, who meet regularly and therefore probably have a denser network, characterized by less superficial relationships for which etiquette is presumably less important.

Second, our research is one of the very few studies on the effects of learning on trust using longitudinal survey data. In this respect, our results have higher external validity than comparable studies using experimental data. By contrast, a limit of our approach is that, unlike in experimental studies, we do not have any information about the actual behaviour of our respondents. Consequently, our results support effects of learning concerning *attitudes* rather than behaviour. Since actual behaviour is not observed, we cannot make any claim concerning either how these attitudes translate into behaviour, or how actual behaviour influences trusting attitudes.

Third, the response rate was about 90 per cent. In general, missing data constitute a severe problem, particularly when studying complete networks. Given additional analyses, including sensitivity analyses, which we do not discuss in the article, the problem seems moderate, as far as the results on learning effects are concerned. In fact, these results were consistent across different models that we estimated and they were not significantly affected by the inclusion of control variables. By contrast, the results concerning control variables are not so robust. Typically, they vary depending on which model is estimated and which other variables are included in the model. This is not surprising, as control variables vary only across respondents and the respondents are only 40. Accordingly, although they are not implausible, the reported effects of our control variables should not be taken too seriously. For the same reason, we were not able to include other potentially interesting individual attributes, such as seniority.

Fourth, we study the relationships of trust and communication existing among the employees by looking at four snapshots taken 3 months after each

other. Doing this, we implicitly assume that the relations observed at the first time point coincide with the origin of this network. It would be interesting to replicate the current analysis on a complete network observed from its origin—for example, a network of first year high school freshmen—to see if our results are robust.

Fifth, analysing four snapshots, we ignore what happened in the 3 months elapsing between each of them. This problem could be better addressed applying statistical models for the evolution of networks, which assume that networks evolve continuously through time and are designed to model unobserved network changes (Snijders, 2005). However, at the current state of the art, the statistical package for the analyses of these models cannot be used to model the co-evolution of two networks changing simultaneously, as we hypothesize here. Further developments in this line of research could profit from both availability of more sophisticated statistical tools to analyse such dynamic data, as well as from the collection of new dynamic network data.

Notes

1. For reader friendliness, we will refer to Ego and Alter using female and male pronouns, respectively.
2. However, models of network control generally adopt forward-looking rationality: it is the concern for future losses caused by a bad reputation that influences the actions of the actors.
3. The original wording was in Dutch. Nuances might have been lost in the translation.
4. Consequently, if $y_{kj}^{t-1} = 0$, $p_{kj}^{t-1} = 0$. If Tertius' trust attitude versus Alter is neutral, he or she will release neutral information to Ego. This implies that neutral information has no effects on Ego's assessment of Alter's trustworthiness.

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