



Testing the impact of targeted team building on project team communication using social network analysis

Julien Pollack^{*}, Petr Matous

School of Civil Engineering, Building J05, University of Sydney, Camperdown, NSW 2006, Australia

Received 17 July 2018; received in revised form 6 February 2019; accepted 24 February 2019
Available online xxxx

Abstract

Communication and teamwork are key determinants of whether a project will be delivered successfully. Team building is often used as a way of improving patterns of team interaction. This research tests the impact of a standardised and repeatable team building protocol on communication in a project team. It builds on the theory that increasing the interconnection within a team communication network will lead to enhanced project outcomes. A longitudinal Social Network Analysis approach was used to diagnose the patterns of communication in a project team, inform planning of the team building intervention, and test the impact of the intervention on team communication. Over a three-month period, the team building resulted in a significant change to project team members' comfort discussing personal matters, and the frequency with which they discussed personal and work-related matters.

© 2019 Published by Elsevier Ltd.

1. Introduction

Projects involve groups of people collaborating under stressful conditions. We expect them to deliver innovative solutions to emergent problems, to anticipate and respond to risks over which they have little control, and to find a delicate middle ground between the, often contradictory, demands of different stakeholder groups. The demands we place on projects teams are high. This can result in significant stress on working relationships. A project will rarely be successful if the team of people responsible for its delivery cannot work together effectively, and yet only a small amount of research in the project management literature has focused on how to form and develop effective project teams.

The importance of teamwork in project management should not be underestimated. Improvements to team processes have a positive correlation to the performance of a team (Thomas et al., 2008, p. 9), and social processes play a significant role in project delivery (Calamel et al., 2012). There is a strong

relationship between project success and team building, and team building partially moderates the effects of transformational leadership on project success (Aga et al., 2016). Team building can also promote greater sharing of mental models between team members, greater mutual understanding, and an increased effort from team members (Hsu et al., 2011).

Although previous research has acknowledged the link between team building and project success, there is still a great deal of work to be done in understanding how project teams can be strengthened, and the ways that team performance affects projects (Baiden and Price, 2011, p. 129). Previous research has paid insufficient attention to how teams affect project outcomes (Scott-Young & Samson, 2008). In particular, no research could be found in the project management literature that tests the impact of specific, repeatable, team building practices, and explores how they impact upon teamwork.

This paper looks at the impact of relationship building in project teams, particularly focusing on how it affects networks of communication. Effective communication is an essential aspect of teamwork, with one in five projects rated as unsuccessful because of poor communication (PMI, 2013). The purpose of this paper is to understand how a team building technique affects a communication network in a project team.

^{*} Corresponding author.

E-mail addresses: julien.pollack@sydney.edu.au (J. Pollack),
petr.matous@sydney.edu.au (P. Matous).

The paper also demonstrates the way that Social Network Analysis (SNA) can be used to test and measure the ways that an intervention impacts upon the social processes within a project team.

2. Literature review

This research will use the definition of team building as “...the formal and informal team-level interventions that focus on improving social relations and clarifying roles as well as solving task and interpersonal problems that affect team functioning” (Klein et al., 2009, p. 183). The goal of most team building is to improve the integration of a team. Increased integration improves the effectiveness of teams (Baiden and Price, 2011, p. 135). A fully integrated team is one that “...has a single project focus and objectives; boundaries between individuals are diminished and team members work towards mutually beneficial outcomes through the free sharing of information” (p. 129). Social Identity Theory provides some clues as to the significance of team integration for team performance. This theory suggests that when team members personally identify with the group, they are more likely to contribute to the welfare of the group and to commit to common goals, despite adversity (Ballesteros-Pérez et al., 2012).

Although the effectiveness of a team can have significant tangible impacts on the time and cost of a project, teamwork is typically regarded as a soft skill with few clear guidelines or exploration of its impact on project performance (Thomas et al., 2008, p. 105). There is a lack of research in this area, and a need for further exploration of how to build project teams (Aga et al., 2016). Although it remains a comparatively under-developed field of research, trends can be seen in previous publications, including a broad focus on two areas: developing a shared understanding between team members; and addressing relational issues, such as commitment, norms, and trust. These topics will be discussed separately.

2.1. A shared understanding

Clear goals are a critical success factor for projects (e.g. Boddy and Macbeth, 2000; Calamel et al., 2012). Projects are typically expected to start with a pre-determined business plan, clearly defined constraints and objectives, and the role of project management is to deliver to that pre-defined problem (Hobbs and Miller, 2002, p. 42). However, not all projects either do, or can, start with unambiguous goals (Turner and Cochrane, 1993). In some cases, the front-end of projects needs to emphasise the process of capturing clear and convincing objectives (Joham et al., 2009, p. 788). In other cases, it is common for goals to remain a matter of negotiation throughout much of the delivery process. When goals cannot be defined unambiguously, Nogueira and Raz (2006, p. 8) have found a need to allow a team to adapt as new situations emerge.

Although it may not always be possible to clearly define goals due to uncertainty or the expectation of change, it is possible to work towards a shared team understanding of the

situation and its constraints. This is important, as shared task understanding and shared project vision are crucial for team performance (Carless and De Paola, 2000, p. 83; Hsu et al., 2011, p. 2; Lee et al., 2015, p. 804). A well-developed project vision facilitates a shared understanding organisational goals (Han and Hovav, 2013, p. 381), provides a common context for communication between team members, and plays a role in improving the effectiveness of knowledge sharing (Lee et al., 2015, p. 799). It also facilitates the process of integrating team members (Ballesteros-Pérez et al., 2012, p. 902). This suggests that team building exercises that focus on developing a shared vision of goals and objectives can assist with team integration.

Knowledge sharing also plays a vital role in team integration and the development of a shared understanding. It has been identified that “...knowledge sharing among project team members is crucial for project performance” (Han and Hovav, 2013, p. 378), and that a team's ability to share knowledge has a crucial impact on the success of a project (Hsu et al., 2011, p. 1). Other research has found evidence that a team's ability to share knowledge is strongly impacted by the social relationships within the team (Chang et al., 2013, p. 253), and that this contributes to the ways that embodied and tacit knowledge are socialised (Leal-Rodriguez et al., 2014, p. 898).

Shared knowledge has been found to provide a common frame of reference, and to increase the chance that new knowledge will be accurately evaluated for relevance (Chang et al., 2013, p. 253). Lee et al. (2015, p. 798) argued that developing the kinds of positive relationships between team members that allow for effective knowledge transfer are important because they facilitate collaborative problem solving, in real time, without hesitation. This is similar to what He (2012, p. 65) refers to as ‘team cognition’; “...the mental models collectively held by a group of individuals that enable them to accomplish tasks by acting as a coordinated unit”. Without appropriate levels of team cognition, He asserts that team members will have a reduced ability to negotiate solutions, coordinate activities, and share new knowledge. Developing a vision and goal, and their impact upon team formation, and knowledge sharing, appear to be fundamental to effective project management.

2.2. Effective intra-team relationships

Stable patterns of behaviour within a team facilitate the emergence of relational norms (Chang et al., 2013, p. 254). Relational norms, in turn, influence the relational structure of the team and individual behaviour. The action of any individual is not independently determined through discrete rationality. Individual behaviour is affected by issues of “...normative conformity (socially accepted standards of conduct about principled behavior) and affective bond (emotional attachments to certain people and organizations)...” (He, 2012, pp. 63–4). If a team's relational norms can be changed to focus on positively reinforcing patterns of behaviour, instead of patterns of blame attribution, and systemic withholding of information, the team's performance may improve.

Trust is a particularly significant relational norm between team members. Increased levels of trust improve the overall efficiency of a project team (Chow et al., 2012, p. 927). Trust is a factor in collaboration success (Chiocchio et al., 2011; Herzog, 2001), and has been linked to project team performance (Lee et al., 2015, p. 804). Higher levels of trust can reduce negotiation costs (Chow et al., 2012, p. 927), and improve a team's ability to innovate by reducing transaction costs (Fukuyama, 1995, p. 27).

Trust has also been positively correlated with psychological safety; a necessary precursor for learning. For effective team learning, team members need to be able to express themselves without fear of criticism (Savelsbergh et al., 2015, p. 407). Some authors refer to psychological safety and trust, shared vision, and a network of useful contacts derived from positive intra-team relationships as social capital (Lee et al., 2015, p. 798). According to Adler & Kwon (2002, p. 23), social capital is "... the goodwill available to individuals or groups. Its source lies in the structure and content of the actor's social relations..." The social capital of a team depends on its members' ability to access resources in their aggregate distributed social networks. It can play a strong role in how a project team responds to change and makes the most of opportunities (Lecoutre and Lièvre, 2010, p. 57). Increased levels of social capital within a team are associated with high levels of collective cooperative behaviour and team cohesiveness (Han and Hovav, 2013, p. 379).

It takes time for social capital to develop naturally, as relationship duration is a significant determinant of how much team members trust each other (Buvik and Rolfsen, 2015, p. 1485). Similarly, team integration is facilitated by the natural accumulation of a common set of experiences and memories about their beliefs, values, and relationships over time (Leal-Rodriguez et al., 2014, p. 899). However, when managing projects, it is often difficult to take the time needed to develop trust between team members due to pressure on the project team to start execution and delivery as soon as possible.

Swift Trust Theory (Meyerson et al., 1996) provides an explanation of how teams in temporary organisational structures can act as if they trust one another, despite not having had sufficient time to develop trust through continued exposure, as is usually the case for time-dependant trust.

"Temporary systems exhibit behaviour that presupposes trust, yet traditional sources of trust – familiarity, shared experience, reciprocal disclosure, threats and deterrents, fulfilled promises, and demonstrations of nonexploitation of vulnerability – are not obvious in such systems." (Meyerson et al., 1996, p. 167).

Swift Trust Theory argues that members behave as if trust were present, and only later verify or change their beliefs when they have accrued sufficient experience of others' behaviour. While research into swift trust helps to explain how teams come together and operate with some semblance of the relationship they might have had if they had been working together for years, it neither sufficiently explores how to improve relationships in situations where participants do not enjoy a positive interpersonal dynamic, nor explores how to transition from the semblance of trust to something more lasting. In these cases, specific team building activities may be necessary. The benefits

that can be accrued from strong intra-team relationships, and the time it takes for these to develop naturally, makes techniques that can help teams rapidly increase their cohesion particularly significant for project management.

Previous research on project teams have demonstrated that positive intra-team relationships, a sense of psychological safety, and trust, all play a significant part in the effectiveness of a team, and subsequently the success of the projects they manage. However, a striking omission in this stream of research relates to its level of abstraction. As identified by Aga et al. (2016), there are many interpretations of team building. However, none of the reviewed research addresses specific techniques for team building, or directly evaluates the effectiveness of repeatable procedures that may be followed in practice. Two different interventions, both called 'team building', may have barely comparable impacts on a team. It is known that team building is generally beneficial. Not much is known about which specific aspects of team building are beneficial, the ways in which they are beneficial, or how they may be implemented in practice.

The purpose of this research is to address this gap by exploring whether a clearly defined and repeatable team building technique has an impact on team behaviour, particularly focusing on team communication. Communication was chosen as the focus of this research, because of its direct association with project success (PMI, 2013), its fundamental role in the process of creating shared understanding discussed above, and because comfort with communication can be related to issues of trust and social capital.

2.3. Social networks analysis

Improvements in project communication are a result of an increased ability to disseminate information through a network of actors. However, improved team communication is not just a simple aggregate of improvements of separate communication links between the team members. To understand how team building affects patterns of communication, it is useful to understand it from a network perspective. Social Network Analysis (SNA) was chosen as a way to address this, as it provides the opportunity to understand communication at both the individual level, and as a network of interactions at the team level.

SNA is a way of analysing the structure of social groups using tools based on graph theory (Scott, 2009). The webs of relationships between group members are conceptualised as networks of links between nodes that represent the members (Kadushin, 2012). SNA has been applied to the study of knowledge and friendship networks in diverse fields, including organisation studies (Bellotti et al., 2016; Brennecke and Rank, 2016; Lomi et al., 2013; Snijders et al., 2013; Zappa and Lomi, 2016) and management studies (Ahuja et al., 2009; Majumder and Srinivasan, 2008; Ryall and Sorenson, 2007) to examine formal and informal structures of teams and organizations. There is also a wide body of SNA research investigating social capital (e.g. Lin, 2001). These previous studies suggest that SNA would be an appropriate way of exploring the impact of a team building intervention on a project team.

Social network links may represent various types of expressive and instrumental information-sharing relationships. On a given set of nodes (i.e. group of individuals), the definition of a network link (e.g., casual communication relationship or instrumental help relationship), determines the type of the network in focus (e.g. casual communication network or instrumental help network). In weighted networks, network links may have diverse strength (e.g. daily communication versus monthly communication). In directed networks, a link from A to B may differ from a link from B to A (e.g. A trusts B but B does not trust A). In multiplex networks, several networks defined by different types of relationships between the same set of nodes are analysed jointly (e.g. a group of people is interconnected by friendship relationships on one layer and contractual obligations on another) (Matous et al., 2014; Mucha et al., 2010; Snijders et al., 2013).

2.3.1. SNA in project management research

There has been a considerable growth of the use of SNA in project management research over the last decade (Zheng et al., 2016, p. 1214), with an emphasis on stakeholder risks in construction project management in China. For example, Mok et al. (2017a) analyses key stakeholder networks in the construction of a Chinese opera house and Mok et al. (2017b) explored stakeholder concern interdependencies in a Chinese infrastructure project. Yu et al. (2017) analysed by SNA the relationships between social risks related to housing demolition in China, and Yang et al. (2016) used SNA in a China-Australia comparison of stakeholder risks in green building development. In other countries, SNA has been used to explore the inter-organisational relationships in construction projects to understand how a contractors' network position affected their bid success (Sedita and Apa, 2015). In addition, Koops et al. (2017) analysed three case studies of infrastructure construction PPP projects, developing networks based on an analysis of team members' task responsibility on projects. Readers interested in further exploration of the use of SNA in construction project management are referred to Zheng et al.'s (2016) structured review of this literature.

Other studies outside construction project management have used SNA to emphasise social factors affecting project management. For example, Hossain (2009) conducted an SNA analysis of email data, and demonstrated that informal network centrality confers more influence in a project than formal organisational position. Pinheiro et al.'s (2016) research also bears relevance to the research presented here. Their study focused on a variety of social capital dimensions, and their relationship to resource sharing in research and development projects. They found that social capital explained resource sharing. Specifically, shared commitment and vision were found to be particularly strong indicators of whether partners would share resources. Other research has found strong correlations between expressive (personal) communication networks and instrumental (work-related) communication networks in project settings (Pollack and Matous, 2018). These results are comparable to research by Carless and de Paola

(2000) that found evidence suggesting that social cohesion may be a necessary precondition for task cohesion.

SNA research in projects has also investigated the impact of network efficiency on project outcomes. The idea behind network efficiency is that the creation and maintenance of each network link requires effort, and that it may be more efficient to get information through 'second-hand' links of your partners, rather than maintaining direct ties to each of them (Burt, 1992). Network efficiency is higher if more network actors can be reached indirectly through a smaller number of direct contacts. However, Kratzer et al. (2010) found that network efficiency was negatively correlated with the tendency to achieve creative and novel outcomes in projects, indicating the importance of dense networks of personal contacts. Teams "...that have a wider range of informational links to other organizational teams are better able to realize creative novel and feasible output" (p. 434). They found direct contacts to be essential for good functioning of project teams, providing a contrasting position to Burt's (1992) theory.

3. Methodology

The research explores the impact of a team building exercise on project team communication. The relationship building exercise was designed by Aron et al. (1997). It focuses on developing positive relationships through a process of personal self-disclosure; a structured conversation in which pairs of participants get to know each other better at a personal level. This relationship building exercise was chosen because it has been shown to have a statistically significant impact on positive affect between participants. It was anticipated that improving positive affect within a team could have an impact on internal team trust, and patterns of knowledge sharing. Moreover, the exercise is described through a detailed and reproducible procedure.

Studies that have applied this process include Vacharkulksemsuk and Fredrickson's (2012) investigation of the effect of self-disclosure on interaction quality and behavioural synchrony. It has been used to study closeness in pairs (Sprecher et al., 2012), and how specific patterns of interaction affect the development of relationships (Sprecher et al., 2013). This process has also been used to study relationship building within small groups (Slatcher, 2010), and was adapted by Sedikides et al. (1999) for shorter intervention periods.

Given that the process described by Aron et al. (1997) has been shown to increase positive affect, it was hypothesised that this process would have a positive impact on patterns of personal communication. Given that previous research (Pollack and Matous, 2018; Carless and De Paola, 2000) has demonstrated a correlation between personal communication networks and work-related communication, it was hypothesised that changes to personal communication networks could influence work-related communication networks. The hypotheses were expressed as follows:

- H1) Comfort with personal communication can be improved using a self-disclosure team building exercise;

- H2) The frequency of personal communication can be increased by a self-disclosure team building exercise;
- H3) Comfort with work-related communication can be improved using a self-disclosure team building exercise; and
- H4) The frequency of work-related communication can be increased by a self-disclosure team building exercise.

Data was collected from of one team of twenty one project management staff within a single management division of an Australian organisation. This division primarily focused on event project management. The team was composed of two groups who were in the process of merging their management processes. One group had historically been responsible for the delivery of a very prominent series of projects, delivered annually, with a one and a half-year planning cycle. The project involves the participation of a wide variety of private contractors, state government, local councils, and emergency services. To preserve the anonymity of the participants, the project is not described in more detail, as the project typically receives significant media attention. The other group was responsible for a large variety of smaller projects with much shorter planning cycles, that may achieve state, but not typically national or international media attention. The teams were in the process of merger at the time of writing, both coming under a single management structure, to allow for increased resource sharing between the groups.

3.1. *The research process*

The research process can best be communicated as a series of four steps:

- 1) The first social network survey;
- 2) Selecting the intervention pairs;
- 3) The relationship building intervention; and
- 4) The second social network survey.

3.1.1. *The first social network survey*

The research participants were asked to rate their interaction with each of their co-workers on four questions:

1. In the last month, how often did you share your personal matters with the following person? (1 – Multiple times a day, 2 – Once every day, 3 – Multiple times a week, but not daily, 4 – Once a week, 5 – Less than once a week, 6 – not in the last month)
2. Even if you typically do not talk to this person often, imagine you were in a situation where you had to discuss an issue from your personal life with them, how comfortable would you feel, on a scale of 1–10 (1 – Very uncomfortable, 10 – Very comfortable)?
3. In the last month, how often did you share work-related matters with the following person? (1 – Multiple times a day, 6 – not in the last month)
4. Even if you typically do not talk to this person often, imagine you had to raise and discuss a significant work-related

mistake with them, how comfortable would you feel discussing it with this person, on a scale of 1–10?

The responses were collected via structured interviews. Structured interview was chosen over survey responses because it provided the opportunity to address informants' concerns about the study. As the team was going through the process of merging two previously distinct units, there was some concern that the research data would be used to inform performance appraisals. Interviews gave the researchers an additional opportunity to remind the research participants about the purpose of the work, previously distributed on participant information sheets, and to address any questions that individuals had not brought up at the initial briefing session. This proved effective in reassuring participants. Use of an interviewer also gave the opportunity for question clarification. Nineteen, of the twenty one members of the project team, provided valid responses. One declined to participate, and one resigned shortly after the research process commenced.

To reduce the likelihood that a respondent would unthinkingly give the same score for both pairs of questions, the interviewer asked the respondent to rate all individuals against a single question, before moving on to the next question and reading through the list of names again. The same experienced interviewer conducted all interviews and coded the questions based on instructions and training by the authors.

The results of this survey were used to construct the following multiplex, directed, weighted social networks.:

1. Participants' comfort in discussing personal matters;
2. Participants' frequency of discussing personal matters;
3. Participants' comfort in discussing work-related matters; and
4. Participants' frequency of discussing work-related matters.

3.1.2. *Selecting the intervention pairs*

The purpose of this step was to determine who should be paired with whom for the relationship building intervention. The intention was to decide which specific relationships in the network would be most likely to benefit from the relationship building exercise, and which relationships, if strengthened, would likely have the greatest impact upon the operation of the network as a whole. The final selection of pairs for the relationship building exercise was based on a three-step process.

Step 1: Participants were asked whether there was anyone they would be interested in being paired with for the relationship building exercise, or whether there was anyone they would prefer to not be paired with. All negative preferences were taken into account, ensuring that no one was paired with someone they explicitly did not want to be paired with. It was not possible to respect all positive preferences, and to accommodate constraints from the following steps.

Step 2: An initial set of pairs was created, based on participants' responses to the first social network survey. As the relationship building exercise directly addressed aspects of personal self-disclosure, it was anticipated that the exercise

would have the greatest impact on the measure of personal communication comfort. Pairs were chosen to:

1. minimise the average scores for mutual comfort in personal communication; and
2. bridge structural holes in the personal communication comfort network.

Selecting pairs based on pre-existing minimum scores gave the greatest opportunity to increase personal communication comfort scores, and thus the greatest possibility of increases to network density. According to research by Kratzer et al. (2010), this would theoretically reduce the network efficiency, and increase the tendency to achieve creative and novel outcomes within the project team.

Fig. 1 shows a subset of the personal communication comfort network from the first social network survey. In most of the following sociograms, there is a split in the middle, separating two relatively more interconnected parts of the network. The presence of relatively more interconnected cohesive subgroups in data (see Wasserman and Faust, 1994 on this topic) can be quantitatively examined by Faction Analysis (Borgatti et al., 2014). Faction analysis confirmed the visual intuition and uncovered two “factions” in this network. The smaller of these factions is consistently situated on the bottom right of Figs. 1 to 5. The thick grey line in Fig. 1 indicates the structural hole in this network. Where possible, pairs were chosen to bridge this structural hole, as structural holes represent gaps in the network (Burt, 1992). In this case, the structural holes in the communication networks represented barriers to effective communication in the team.

Step 3: The proposed list of pairs was discussed with the group's manager, to understand whether there were any interpersonal considerations that should be taken into account, which had not been captured by the survey. This three-step process resulted in the selection of ten pairs of individuals who would go through the relationship building exercise together.

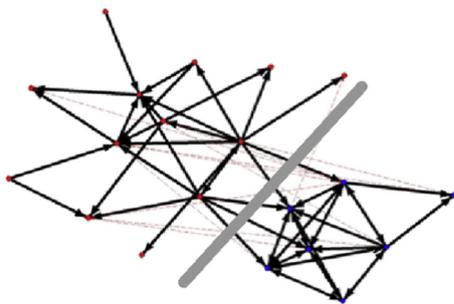


Fig. 1. Network of personal communication comfort. Each circle represents a team member and each arrow points from the respondent to their reported communication partner. Thick lines highlight relationships with the highest levels of communication comfort (10 out of 10); thin dashed lines represent relationships with the lowest levels of communication comfort (0 out of 10). The area in the middle with relatively few comfortable relationships and many uncomfortable relationships is a structural hole between the two factions in the network.

3.1.3. The relationship building intervention

The relationship building intervention was conducted to closely follow the protocol described in Aron et al. (1997). The exercise was conducted in an isolated meeting room. This was chosen to give the participants a sense of privacy and separation from their daily work commitments. The duration of the relationship building exercise was 45 min, although some pairs elected to continue their conversation for a longer period.

3.1.4. The second social network survey

A second survey was conducted after the relationship building exercise, repeating the four main questions. The purpose of the second survey was to understand whether, and how, the team building exercise had affected the communication networks in the team. This survey occurred approximately three months after the first survey. The data was triangulated through interviews, observations, and feedback from participants. Although the content of these interviews is not included in this research paper, this data provided assurance that the results of the network visualisation was representative of the participants' perceptions of their social networks.

4. Analysis

Network diagrams (sociograms) were developed for each of the eight communication networks. Drawing sociograms is one of the main ways to present and explore social networks (Scott, 2009). McGrath et al. (1996) demonstrated that sociograms can be used to correctly infer network structure if the diagrams are constructed such that the physical distance between nodes in their layout corresponds to the number of steps between them. Similar to geographical maps which apply systematic rules to represent complex reality in two dimensional visual layouts, rigorously developed sociograms make the underlying structural and mathematical properties of a network visually comprehensible (Scott, 2009).

The full dataset represent completely interconnected networks: every team member knows and communicates with every other team member. Visualizing the structure of networks in which everyone is connected to everyone else is difficult to read, and generally uninformative. To facilitate interpretation of the networks, only a subset of the network edges have been included in each of the diagrams below, to make it easier to see the structure of the strongest relationships between actors.

The layout of the sociograms was determined by the Spring Embedding algorithm with Node Repulsion in Ucinet (Borgatti et al., 2014) and visualized in Netdraw (Borgatti, 2002). This algorithm pulls more interconnected nodes closer together (as if the links were springs) and disconnected nodes further apart (as if they were particles driven by repulsive forces). The final layout minimizes the energy of the system. The method is similar to multi-dimensional scaling widely used in social sciences (Robins, 2015).

Fig. 2 represents the network of respondents' comfort with personal communication, before and after the relationship building exercise. Bold lines go from respondents to individuals with whom they were very comfortable (score 10) discussing personal

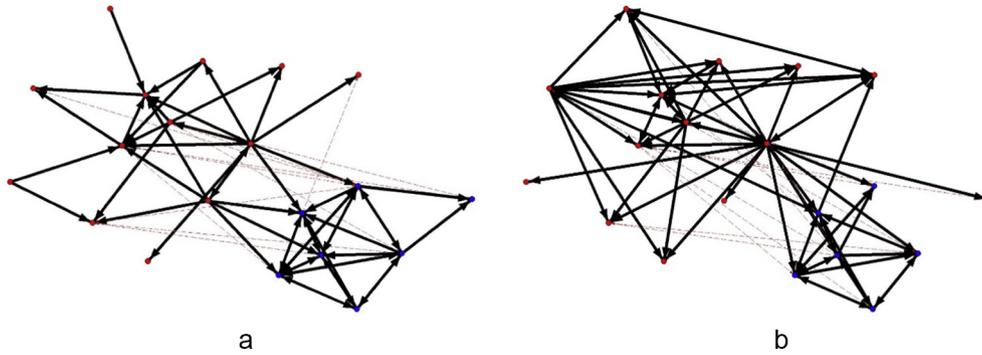


Fig. 2. (a) Comfort with personal communication before the intervention. (b) Comfort with personal communication after the intervention.

matters. Dotted lines go from respondents to individuals with whom they were very uncomfortable discussing personal matters (score 1). It is interesting to note that all of the 1 scores occur between the two cliques, confirming the results of the Faction Analysis.

The bootstrap technique was used to compare the strength of the relationships in each network before and after the intervention. The procedure tests whether the mean difference between two sets of observations is zero. This method is analogous to the classical paired sample *t*-test for estimating the standard error of the difference. In our case the pairs of observations are the strength of each relationship before and after the intervention (Konietzschke and Pauly, 2013). There is an obvious visual difference between Figs. 2a and 2b, with significantly more links between nodes bridging the structural hole (Fig. 1) in Fig. 2b, than in Fig. 2a. Additional links between participants in the upper left quadrant of Fig. 2b are also apparent. However, at the level of the network as a whole there was no statistically significant increase in comfort with personal communication following the relationship building exercise.

Fig. 3 represents the network of respondents' frequency of personal communication, before and after the relationship building exercise. Bold lines go from respondents to individuals with whom they communicate daily about personal matters. Dotted lines go from respondents to individuals with whom they had not communicated about personal matters in the last month. Overall, following the intervention, the average score for responses to the question of frequency of personal communication had significantly increased (bootstrap *t*-test

pseudo-*p* = .0038). There had been a significant increase in network density between the two surveys, indicating that the participants were overall discussing personal matters much more frequently. The differences between Figs. 3a and 3b can be seen in increased linkages in the upper left quadrant of Fig. 3b, and with a significant increases in linkages spanning the structural hole, particularly in terms of strong link to a central node in the bottom right of Fig. 3b.

Fig. 4 represents the network of respondents' comfort with work-related communication, before and after the relationship building exercise. At the level of the network as a whole, there was no statistically significant increase in comfort with work-related communication following the relationship building exercise. The differences between Figs. 4a and Fig. 4b are difficult to interpret visually. A general increase in high-ranked links is apparent, but this is largely diffused across the network, and cannot be isolated to a single domain or cluster.

Fig. 5 represents the network of respondents' frequency of work-related communication, before and after the relationship building exercise. Overall, following the intervention the average response to the question of frequency of work-related communication had significantly increased (bootstrap *t*-test pseudo-*p* = .0098). There had been a significant increase in network density between the two surveys, indicating that the participants were discussing work-related matters much more frequently. The significant change between the social networks represented in Figs. 5a and 5b is apparent in the increase in strong links across the structural hole (Fig. 1), showing increased bridging between the cliques in the upper left, and lower right of these figures. There is also a general increase in

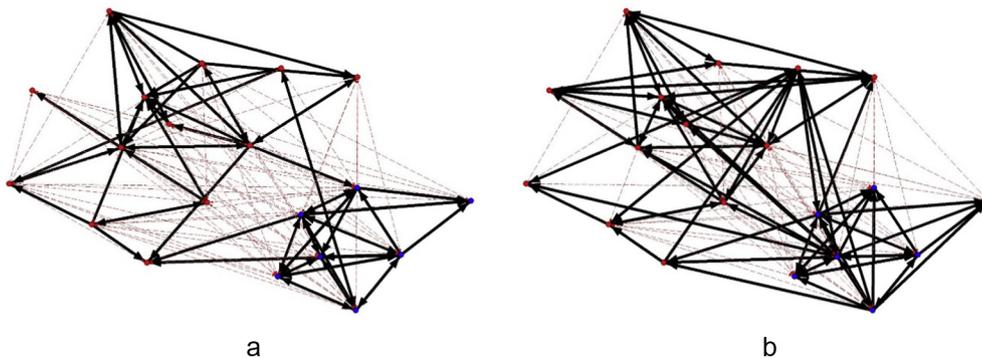


Fig. 3. (a) Frequency of personal communication before the intervention. (b) Frequency of personal communication after the intervention.

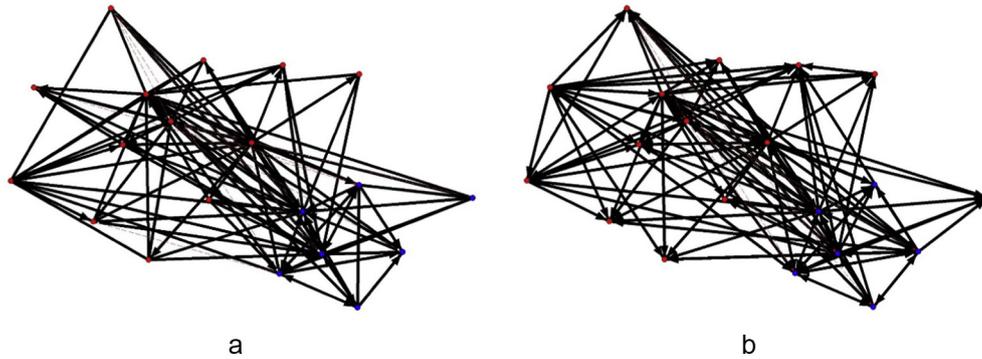


Fig. 4. (a) Comfort with work-related communication before the intervention. (b) Comfort with work-related communication after the intervention.

the strength of the links in the upper left clique, suggesting an increase in interaction within this clique over the intervention period.

In summary of the overall changes, following the team building exercise, people in the network started to talk to each other more about work-related and personal issues, but there was little overall change in how comfortable they were talking to each other. Before the intervention, the frequency of work-related communication was higher than personal communication. However, the frequency of personal communication increased more steeply, with similarly high levels measured for both networks following the intervention. Both before and after the intervention, the team members were more comfortable talking to each other about work-related matters, than personal matters.

However, it is difficult to exclusively attribute the change in the communication networks to the relationship building exercise. This team was composed of two groups coming together under a single organisational structure. It would be expected that their communication networks would be evolving, as they learned how to work together. To develop a better understanding of how the team building activity affected the communication network, it was necessary to contrast the change in relationship between pairs who worked together in the team building exercise, with their relationships with others.

The relationships between the pairs who went through the team building exercise were examined to understand the differences between their Survey 1 and Survey 2 responses,

using a two-tailed sample mean t-test (Table 1). Significant changes were found in terms of the pairs' personal communication comfort, personal communication frequency, and work-related communication frequency. The average rating for comfort with personal communication for the intervention pairs changed from 4.9 to 6.8 out of 10. The most common response for personal communication frequency for the pairs involved in the team building has changed from “not in the last month” to “once a week”.

The impact of the team building exercise can also be examined by comparing the change in relationships between pairs who went through the exercise to the changes in the relationships that were not the focus of the intervention. Fig. 6 shows the change in average link weights for the intervention pairs, compared to the change in average link weights for the non-intervention pairs. The average increase in communication across all measures was stronger for the intervention, and there is a particularly strong change for both aspects of personal communication.

5. Discussion and limitations

A high-performing team is an essential aspect of a high-performing project, and yet there is surprisingly little research that investigates ways of improving the way a teamwork. Team building activities can broadly be separated into those that develop a shared direction for a project, and those that develop positive intra-team relationships, but few studies have sought to

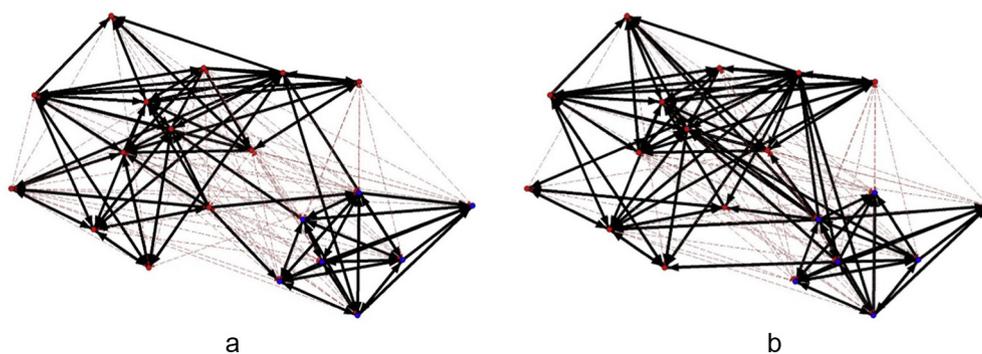


Fig. 5. (a) Frequency of work-related communication before the intervention. (b) Frequency of work-related communication after the intervention.

Table 1

Significance of response changes for intervention pairs (Responses to measures of communication comfort were measured on a continuous scale of 1–10 {1 – very uncomfortable, 10 – very comfortable}. Responses to measures of communication frequency were measured on a scale of 1–6 {1 – Multiple times a day, 2 – Once every day, 3 – Multiple times a week, but not daily, 4 – Once a week, 5 – Less than once a week, 6 – not in the last month}. The *p*-value column shows the significance of the difference between the surveys for each measure).

	Mode response		Median response		Mean		p-value
	Survey 1	Survey 2	Survey 1	Survey 2	Survey 1	Survey 2	
Personal comfort	5	8	5	7	4.90	6.80	0.0037
Personal frequency	6	4	5	4	5.05	3.80	0.0000
Work-related comfort	8	10	8	8	7.45	8	0.5916
Work-related frequency	6	6	5.5	4.5	4.80	4.35	0.0351

test whether, and how repeatable team building activities have specific impacts on project teams.

This research tested four hypotheses:

- H1) Comfort with personal communication can be improved using a self-disclosure team building exercise;
- H2) The frequency of personal communication can be increased by a self-disclosure team building exercise;
- H3) Comfort with work-related communication can be improved using a self-disclosure team building exercise; and
- H4) The frequency of work-related communication can be increased by a self-disclosure team building exercise.

Significant changes were found in terms of the pairs' personal communication comfort, personal communication frequency, and work-related communication frequency. These findings provide support for hypotheses 1, 2, and 4. This evidence suggests that Aron et al.'s (1997) protocol can be used as a team building exercise that can lead to increased levels of comfort with personal communication, and an increased frequency of personal and work-related communication. There was insufficient evidence to support the third hypothesis, that a

self-disclosure exercise can be used to increase comfort with work-related communication.

Part of the significance of this research is that it is arguably the first study to measure the impact on project team communication from a standardised and repeatable team building intervention focused on relationship development through self-disclosure. This research demonstrates that this team building intervention has a significant impact on specific aspects of project team communication. It also provides clear evidence that can be used to support investment in team building in practice.

The paper also illustrates the potential value of SNA for mapping team structures, informing the design of targeted team-building interventions, and communicating the results to stakeholders. Use of a standard network data gathering instrument was used to gain a comprehensive view of the entire structure of communication network within the team. This provided a view of the patterns of communication for the network as a whole. These patterns are not detectable through analysis of individual responses. It allowed for team building to be specifically structured to bridge structural holes in the network. This approach has a potential to for greater application in project management research and practice.

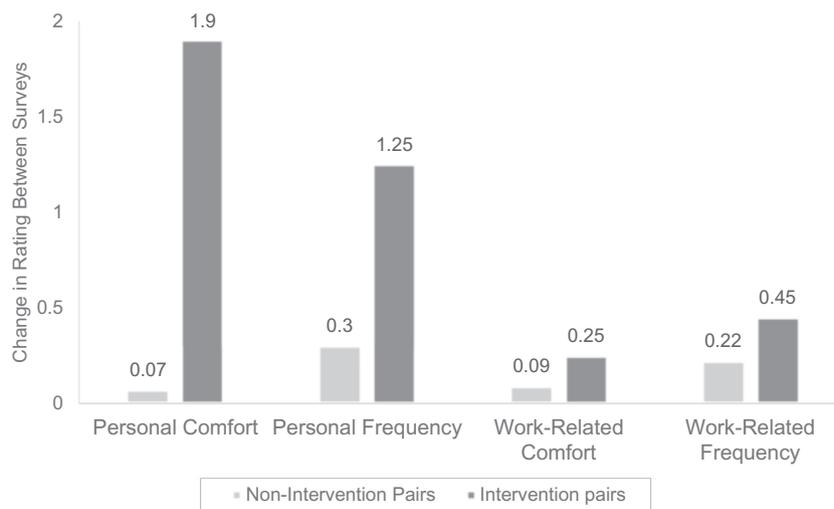


Fig. 6. Difference in average responses for intervention pairs and the whole network. This graph communicates the change in participants' responses to the survey question over the three-month intervention period. For each survey question, there was a more pronounced change in communication and interaction patterns for relationships directly affected by the intervention, than for relationships not directly affected by the intervention.

Any gap within the structure of a communication network among a group of people who are expected to function as a cohesive team may paralyse their performance. However, the standard approach to team building is to attempt to address all of the relationships in the team at once, by taking a whole team on a team building exercise. Such a costly team building approach may not always be justified, as it treats already strong relationships as equivalent to weak relationships and may miss the most critical gaps. Untargeted and indiscriminate collective approaches to team building allow sub-groups of individuals with better relationships to interact with one another during the intervention, while not necessarily strengthening the relationships that need it most.

This research has taken a significantly different approach. A targeted team building places less demand on staff time, by focusing only those relationships where there is the likelihood of significant returns from team building. SNA identified crucial relationships that have the greatest room for improvement out of the entire network. Moreover, the SNA visualisation techniques allowed the participants to assess and appreciate the impact that the improvements of individual communication links had on connecting the overall structure of the team, which was originally composed of two cliques kept apart by relationships of suboptimal communication.

5.1. Limitations of the study

There are limitations to this study that should be considered when interpreting the results, and when considering how they can be applied in other contexts. One limitation relates to the relationship building exercise used in this research. This research used Aron et al.'s (1997) protocol, and caution should be exercised when extending these results to other team building exercises. This exercise requires participants to reveal personal aspects of themselves in a workplace setting, and it should be considered whether this would be acceptable in other cultural settings. The research was set in Australia, and Australian organizations are not known to be particularly tolerant nor intolerant of affective expression in the workplace (Comfort and Franklin, 2014). This may be different in other settings. However, it should be noted that the culture of an organisation, or unit, may be more relevant than the geographical origin of the team members (Holliday, 1999). The implication for future research is that care should be taken in extending these results to other settings, as the national, professional, organisational, and team cultures of the people involved may limit their ability and willingness to participate in comparable interventions.

A further limitation of this research relates to the pair selection process. The intervention pairs were selected on the basis that they had given each other a relatively low score for comfort with personal communication. As a direct consequence, the greatest potential for growth was on measures of comfort with personal communication. Ratings of comfort with work-related communication, and ratings of frequency of personal and work-related communication, may have had less potential for growth, as the pairs were not selected to minimise these scores. If the pairs had been selected on the

basis of one of these other ratings, it is quite possible that the results would have been different. Fig. 6, above, shows the greatest change was occurred in comfort with personal communication, and from these results it remains unclear whether this is a result of the focus of the relationship building exercise, the pair selection process, or some combination of these and other factors.

5.2. Future research

Future research should seek to extend this study with a larger sample, with multiple teams, with additional surveys conducted over a longer period. This would provide the opportunity to understand the relationship between different indicators of project team communication. It is possible that the impact of a team building intervention focusing on personal communication may have an impact on measures such as comfort with work-related communication over a longer period. Future research could involve a randomised process of pair selection, to avoid any bias introduced through the pair-selection process. A larger study could also involve a control group, to provide additional comparison points, and to provide additional control for the relationship development that naturally occurs over time.

6. Conclusion

The research in this paper has sought to understand how a team building intervention affects the network of communication in a project team. The research involved one team of project management personnel that had recently been formed out of two separate groups, following a period of organisational change. Faction Analysis of the network data revealed two largely distinct groups within the team that were consistent with the history of the team. This project provided a good setting in which the efficacy of a team building technique could be tested, and it involved a mix of established relationships, and relationships that were only starting to develop.

It was found that following the team building intervention, over a period of three months, there was a significant increase in the network density of the personal and work-related communication frequency networks. However, comfort with personal and work-related communication did not change significantly over that period. In other words, on average the participants were communicating much more frequently about personal and work-related matters, but their levels of comfort did not significantly change.

Significant changes were also uncovered when the data on the relationships directly affected by the team building intervention were contrasted with those not directly affected. The analysis showed significantly higher levels of comfort with personal communication, and an increased frequency of personal and work-related communication.

To understand the impact of the team building exercise, it was necessary to separately look at the relationships between the pairs who underwent the relationship building exercise. Significant changes were found in the intervention pairs' relationships in the personal communication comfort, personal communication

frequency, and work-related communication frequency networks. These changes were consistently more pronounced for the intervention pairs than for the non-intervention pairs, suggesting that the change can be attributed to the intervention, and not to other external factors.

References

- Adler, P., Kwon, S., 2002. Social capital: prospects for a new concept. *Acad. Manag. Rev.* 27 (1), 17–40.
- Aga, D., Noorderhaven, N., Vallejo, B., 2016. Transformational leadership and project success: the mediating role of team-building. *Int. J. Proj. Manag.* 34, 806–818.
- Ahuja, G., Polidoro, F., Mitchell, W., 2009. Structural homophily or social asymmetry? The formation of alliances by poorly embedded firms. *Strateg. Manag. J.* 30 (9), 941–958.
- Aron, A., Melinat, E., Aron, E., Vallone, R., Bator, R., 1997. The experimental generation of interpersonal closeness: a procedure and some preliminary findings. *Personal. Soc. Psychol. Bull.* 23 (4), 337–363.
- Baiden, B., Price, A., 2011. The effect of integration on project delivery team effectiveness. *Int. J. Proj. Manag.* 29, 129–136.
- Ballesteros-Pérez, P., González-Cruz, M., Fernández-Diego, M., 2012. Human resource allocation management in multiple projects using sociometric techniques. *Int. J. Proj. Manag.* 30, 901–913.
- Bellotti, E., Gaudalupi, L., Conaldi, G., 2016. Comparing Fields of Sciences: Multilevel Networks of Research Collaborations in Italian Academia. Springer, London.
- Boddy, D., Macbeth, D., 2000. Prescriptions for managing change: a survey of their effects in projects to implement collaborative working between organisations. *Int. J. Proj. Manag.* 18, 297–306.
- Borgatti, S., 2002. Netdraw network visualization. Analytic Technologies, Harvard, MA.
- Borgatti, S., Everett, M., Freeman, L., 2014. UCINET. Springer New York, New York.
- Brennecke, J., Rank, O., 2016. Knowledge Networks in High-Tech Clusters: A Multilevel Perspective on Interpersonal and Inter-Organizational Collaboration. Springer, London.
- Burt, R., 1992. Structural Holes: The Social Structure of Competition. Harvard University Press, Cambridge, MA.
- Buvik, M., Rolfsen, M., 2015. Prior ties and trust development in project teams – a case study from the construction industry. *Int. J. Proj. Manag.* 33, 1484–1494.
- Calamel, L., Defélix, C., Picq, T., Retour, D., 2012. Inter-organisational projects in French innovation clusters: the construction of collaboration. *Int. J. Proj. Manag.* 30, 48–59.
- Carless, S., De Paola, C., 2000. The measurement of cohesion in work teams. *Small Group Res.* 31 (1), 71–88.
- Chang, K., Yen, H., Chiang, C., Parolia, N., 2013. Knowledge contribution in information system development teams: an empirical research from a social cognitive perspective. *Int. J. Proj. Manag.* 31, 252–263.
- Chiocchio, F., Forgues, D., Paradis, D., Iordanova, I., 2011. Teamwork in integrated design projects: understanding the effects of trust, conflict, and collaboration on performance. *Proj. Manag. J.* 42 (6), 78–91.
- Chow, P., Cheung, S., Chan, K., 2012. Trust-building in construction contracting: mechanism and expectation. *Int. J. Proj. Manag.* 30, 927–937.
- Comfort, J., Franklin, P., 2014. *The Mindful International Manager*. KoganPage, London.
- Fukuyama, F., 1995. *Trust: The Social Virtues and the Creation of Prosperity*. Hamish Hamilton, London.
- Han, J., Hovav, A., 2013. To bridge or to bond? Diverse social connections in an IS project team. *Int. J. Proj. Manag.* 31, 378–390.
- He, J., 2012. Counteracting free-riding with team morale—an experimental study. *Proj. Manag. J.* 43 (3), 62–75.
- Herzog, V., 2001. Trust building on corporate collaborative project teams. *Proj. Manag. J.* 32 (1), 28–37.
- Hobbs, B., Miller, R., 2002. The strategic front end of large infrastructure projects: A process of nesting governance. PMI Research Conference. Seattle, Washington, PMI, 14–17, July.
- Holliday, A., 1999. Small Cultures. *Appl. Linguis.* 20 (2), 237–264.
- Hossain, L., 2009. Effect of organisational position and network centrality on project coordination. *Int. J. Proj. Manag.* 27, 680–689.
- Hsu, J., Chang, J., Klein, G., Jiang, J., 2011. Exploring the impact of team mental models on information utilization and project performance in system development. *Int. J. Proj. Manag.* 29, 1–12.
- Joham, C., Metcalfe, M., Sastrowardoyo, S., 2009. Project conceptualization using pragmatic methods. *Int. J. Proj. Manag.* 27, 787–794.
- Kadushin, C., 2012. *Understanding Social Networks: Theories, Concepts, and Findings*. Oxford University Press, Oxford.
- Klein, C., DiazGranados, D., Salas, E., Le, H., Burke, C., Lyons, R., Goodwin, G., 2009. Does team building work? *Small Group Res.* 40, 181–222.
- Konietschke, F., Pauly, M., 2013. Bootstrapping and permuting paired t-test type statistics. *Stat. Comput.* 24. <https://doi.org/10.1007/s11222-012-9370-4>.
- Koops, L., Bosch-Rekvelde, M., Bakker, H., Hertogh, M., 2017. Exploring the influence of external actors on the cooperation in public-private project organizations for constructing infrastructure. *Int. J. Proj. Manag.* 35, 618–632.
- Kratzer, J., Leenders, R., van Engelen, J., 2010. The social network among engineering design teams and their creativity: a case study among teams in two product development programs. *Int. J. Proj. Manag.* 28, 428–436.
- Leal-Rodríguez, A., Roldán, J., Ariza-Montes, J., Leal-Millán, A., 2014. From potential absorptive capacity to innovation outcomes in project teams: the conditional mediating role of the realized absorptive capacity in a relational learning context. *Int. J. Proj. Manag.* 32, 894–907.
- Lecoutre, M., Lièvre, P., 2010. Mobilizing social networks beyond project team Frontiers: the case of polar expeditions. *Proj. Manag. J.* 41 (3), 57–68.
- Lee, J., Park, J., Lee, S., 2015. Raising team social capital with knowledge and communication in information systems development projects. *Int. J. Proj. Manag.* 33, 797–807.
- Lin, N., 2001. *Social Capital: A Theory of Social Structure and Action*. Cambridge University Press, Cambridge.
- Lomi, A., Lusher, D., Pattison, P., Robins, G., 2013. The focused Organization of Advice Relations: a study in boundary crossing. *Organ. Sci.* 25 (2), 438–457.
- Majumder, P., Srinivasan, A., 2008. Leadership and competition in network supply chains. *Manag. Sci.* 54 (6), 1189–1204.
- Matous, P., Todo, Y., Ishikawa, T., 2014. Emergence of multiplex mobile phone communication networks across rural areas: an Ethiopian experiment. *Network Sci.* 2 (02), 162–188.
- McGrath, C., Blythe, J., Krackhard, D., 1996. Seeing groups in graph layouts. *Connections* 19 (2), 22–29.
- Meyerson, D., Weick, K., Kramer, R., 1996. Swift trust and temporary groups. In: Kramer, R., Tyler, K. (Eds.), *Trust in Organizations: Frontiers of Theory and Research*. Sage, Thousand Oaks, pp. 166–195.
- Mok, K., Shen, G., Yang, R., 2017a. Addressing stakeholder complexity and major pitfalls in large cultural building projects. *Int. J. Proj. Manag.* 35, 463–478.
- Mok, K., Shen, G., Yang, R., Li, C., 2017b. Investigating key challenges in major public engineering projects by a network-theory based analysis of stakeholder concerns: a case study. *Int. J. Proj. Manag.* 35, 78–94.
- Mucha, P., Richardson, T., Macon, K., Porter, M., Onnela, J.-P., 2010. Community structure in time-dependent, multiscale, and multiplex networks. *Science* 328 (5980), 876–878.
- Nogueira, J., Raz, T., 2006. Structure and flexibility of project teams under turbulent environments: an application of agent-based simulation. *Proj. Manag. J.* 37 (2), 5–10.
- Pinheiro, M., Seródio, P., Pinho, J., Luca, C., 2016. The role of social capital towards resource sharing in collaborative R&D projects: evidences from the 7th framework Programme. *Int. J. Proj. Manag.* 34, 1519–1536.
- Pollack, J., Matous, P., 2018. The Relationship between Personal and Work-Related Communication in a Project Setting. EURAM Conference, 19–22 June, Reykjavik, Iceland.

- Project Management Institute, 2013. *The Essential Role of Communications*. Project Management Institute, Newtown Square.
- Robins, G., 2015. *Doing Social Network Research: Network-Based Research Design for Social Scientists*. Sage, London.
- Ryall, M., Sorenson, O., 2007. Brokers and competitive advantage. *Manag. Sci.* 53 (4), 566–583.
- Savelsbergh, C., Poell, R., van der Heijden, B., 2015. Does team stability mediate the relationship between leadership and team learning? An empirical study among Dutch project teams. *Int. J. Proj. Manag.* 33, 406–418.
- Scott-Young, C., Samson, D., 2008. Project success and project team management: Evidence from capital projects in the process industries. *J. Oper. Manag.* 26, 749–766.
- Scott, J., 2009. *Social Network Analysis: A Handbook*. Sage, London.
- Sedikides, C., Campbell, W., Reeder, G., Elliot, A., 1999. The relationship closeness induction task. *Represent. Res. Soc. Psychol.* 23, 1–4.
- Sedita, S., Apa, R., 2015. The impact of inter-organizational relationships on contractors' success in winning public procurement projects: the case of the construction industry in the Veneto region. *Int. J. Proj. Manag.* 33, 1548–1562.
- Slatcher, R., 2010. When Harry and Sally met Dick and Jane: creating closeness between couples. *Pers. Relat.* 17, 279–297.
- Snijders, T., Lomi, A., Torló, V., 2013. A model for the multiplex dynamics of two-mode and one-mode networks, with an application to employment preference, friendship, and advice. *Soc. Networks* 35 (2), 265–276.
- Sprecher, S., Treger, S., Wondra, D., 2012. Effects of self-disclosure role on liking, closeness, and other impressions in get-acquainted interactions. *J. Soc. Pers. Relat.* 30 (4), 497–514.
- Sprecher, S., Treger, S., Wondra, J., Hilaire, N., Wallpe, K., 2013. Taking turns: reciprocal self-disclosure promotes liking in initial interactions. *J. Exp. Soc. Psychol.* 49, 860–866.
- Thomas, M., Jacques, P., Adams, J., Kihneman-Wooten, J., 2008. Developing an effective project: planning and team building combined. *Proj. Manag. J.* 39 (4), 105–113.
- Turner, R., Cochrane, R., 1993. Goals-and-methods matrix: coping with projects with ill defined goals and/or methods of achieving them. *Int. J. Proj. Manag.* 11, 93–102.
- Vacharkulksemsuk, T., Fredrickson, B., 2012. Strangers in sync: achieving embodied rapport through shared movements. *J. Exp. Soc. Psychol.* 48, 399–402.
- Wasserman, S., Faust, K., 1994. *Social Network Analysis: Methods and Applications*. Cambridge University Press, Cambridge.
- Yang, R., Zou, P., Wang, J., 2016. Modelling stakeholder-associated risk networks in green building projects. *Int. J. Proj. Manag.* 34, 66–81.
- Yu, T., Shen, G., Shi, Q., Lai, X., Li, C., Xu, K., 2017. Managing social risks at the housing demolition stage of urban redevelopment projects: a stakeholder-oriented study using social network analysis. *Int. J. Proj. Manag.* 35, 925–941.
- Zappa, P., Lomi, A., 2016. *Knowledge Sharing in Organizations: A Multilevel Network Analysis*. Springer, London.
- Zheng, X., Le, Y., Chan, A., Hu, Y., Li, Y., 2016. Review of the application of social network analysis (SNA) in construction project management research. *Int. J. Proj. Manag.* 34, 1214–1225.