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Teams as Boundaries: How Intra-Team and Inter-Team Brokerage Influence Network Changes in Knowledge-Seeking Networks

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Abstract

What role does an ego's brokerage location—within a team (intra-team) or outside the team (inter-team)—play in the evolution of an instrumental knowledge-seeking network in terms of both proximal (i.e., within the team) and distal (i.e., outside the team) tie formation and tie decay? We address this question by drawing on literature about social networks, brokerage, and teams. We use temporally separated data from 302 students embedded in 97 teams to test our hypotheses about the impacts of intra-team and inter-team brokerage on proximal and distal network evolution, specifically on four network changes in knowledge-seeking networks: proximal tie formation, proximal tie decay, distal tie formation, and distal tie decay. We find that these four changes depend on individual network brokerage location even after controlling for personality and task characteristics. Specifically, inter-team brokers change their networks both within and outside their teams, whereas intra-team brokers curtail their network changes. We argue that these opposite effects occur because inter-team brokers have greater autonomy than intra-team brokers. This study adds to the ongoing dialog about network evolution in social network literature and to the conversations about brokerage and its location in the context of team-based work.

Keywords: brokerage, brokerage location, network evolution, teams, knowledge-seeking networks

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How Intra-Team and Inter-Team Brokerage Influence Network Changes in Knowledge-Seeking Networks

Networks have been shown to significantly influence individuals, teams, and organizations (Kilduff & Tsai, 2003). Although network studies have established that informal social structures benefit individuals, research has tended to ignore the factors that shape their informal networks (exceptions include Clegg, Josserand, Mehra, & Pitsis, 2016; Parise & Rollag, 2010; Parker, Halgin, & Borgatti, 2016; Sasovova, Mehra, Borgatti, & Schippers, 2010; Schulte, Cohen, & Klein, 2012; Vissa & Bhagavatula, 2012). The prevailing view of networks is a static one and assumes that when individuals form ties with new alters, they retain these ties and do not decay prior ties. However, recent studies on network evolution have questioned both these inertia-based assumptions by showing that networks do change over time (e.g., Sasovova et al., 2010; Schulte et al., 2012) as individuals add new ties and drop prior ones. This revised and dynamic view of networks implies that researchers may be drawing the wrong conclusions about networks if they assume that networks are unchanging. For example, in his seminal work on structural holes, Burt (1992) finds that brokerage is correlated with organizational position. Did brokers get ahead, or did the promoted individuals move to brokerage positions? A dynamic theory of networks (and appropriate research design) can pinpoint the accurate explanation.

Scholars recently began studying the important issues related to network change, and some recent studies have focused on the antecedents as well as the consequences of such change (e.g., Parise & Rollag, 2010; Vissa & Bhagavatula, 2012). However, our understanding of network dynamics is limited on three different fronts. First, studies that view networks as dynamic ignore a key organizational feature—teams—that may shape how networks change over time. Because teams have their unique team identities and team members are more

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interdependent with each other than with outsiders, individuals' networks inside and outside their teams may be shaped differently (Dahlander & McFarland, 2013). This approach to the study of networks within and outside the team is not new (e.g., Balkundi & Harrison, 2006). However, what has been ignored in such network literature on teams is the role that teams play in shaping one's informal ties inside and outside the team.

In the team context, the two basic types of network changes—forming new ties and dropping old ties—become more nuanced when both these changes can occur inside and outside the team. For example, individuals can add ties in their own team by seeking information from their fellow team members (*proximal tie formation*), or they can add ties by seeking out information from individuals outside their team (*distal tie formation*). Similarly, they can cease seeking information from their fellow team members (*proximal tie decay*) or from outsiders (*distal tie decay*). Therefore, network change in a team context manifests in these four types.

Second, our understanding of network change is limited in explaining how prior networks shape future networks. Over 20 years ago, Salancik (1995) urged network researchers to explain how brokerage influences subsequent informal interactions. Since then, the focus of the field has primarily been on how brokerage predicts the career-related outcomes of brokers (Burt, 2005, 2007; Fang et al., 2015), which ignores Salancik's original question about how brokerage influences network change. In this study, we seek to answer this question and to go further by explaining how brokerage in the team context is different because individuals can be brokers inside their teams (intra-team brokerage) by bridging disconnected team members, or they can bridge disconnected alters outside their teams (inter-team brokerage). Previous research finds that each type of brokerage may provide varying levels of autonomy, which is the key benefit of brokerage (Zou & Ingram, 2013). Overall, we seek to understand how the location of brokerage

in terms of intra-team and inter-team brokerage shapes networks inside and outside teams.

Finally, the literature on network change has been based on friendship and advice relationships (e.g., Sasovova et al., 2010; Vissa & Bhagavatula, 2012). We extend this work by focusing on knowledge-seeking (KS) networks for two reasons. First, on a continuum from informal to formal relationships, friendship ties are more informal, whereas KS ties are more formal because they are instrumental in completing tasks. Advice ties lie somewhere in the middle on this continuum because they can provide both task-related information and social support. However, KS ties are more informal than those relationships that are mandated by the organization because one can go beyond the organizational chart to seek out information. Second, KS ties are important in contemporary organizations characterized by team-based, knowledge-intensive, dynamic task environments in which the ability to continually acquire new task- and context-related knowledge from multiple sources is critical for success (Espinosa, Slaughter, Kraut, & Herbsleb, 2007; Hansen, Mors, & Lovas, 2005; Hong & Gajendran, 2018). Successful KS in such an environment would arguably require the focal person to establish links with those who possess the required knowledge and to continually evaluate the utility of these connections and adapt them as knowledge requirements change (Ahuja, Soda, & Zaheer, 2012; Gray & Meister, 2004). As discussed earlier, our goal is to shed light on the role of two different types of brokerage—intra-team and inter-team—on individuals' network changes in terms of KS tie formation and KS tie decay within and outside their team boundaries.

We use temporally separated data from 302 students working in 97 teams to test our hypotheses about how brokerage location (i.e., intra-team and inter-team brokerage) shapes the four network changes in KS networks: proximal tie formation, proximal tie decay, distal tie formation, and distal tie decay. We find that these network changes depend on the ego's

brokerage location even after controlling for personality and tasks. Overall, inter-team brokers are more likely to shape their networks, whereas intra-team brokers are more constrained. We contribute to the ongoing dialog about network evolution in social network literature and to conversations about brokerage and its location in the context of team-based work.

Theoretical Background

Social Network Change

The microfoundations of network change involve two forms of network changes: tie formation and tie decay (Koka, Madhavan, & Prescott, 2006). When two strangers establish a relationship, they form a tie. When two people who were previously tied dissolve their relationship or reduce their interactions, the current tie decays or goes dormant (Dahlander & McFarland, 2013). Individuals are continuously evaluating their instrumental ties and the quality of information flowing from them, and they are thus generally aware that they are altering their network by forming new ties or decaying existing ties (Parker et al., 2016).

However, individuals face different constraints and pressures that limit their network changes. To develop new ties, individuals need opportunities to interact with potential new partners. The lack of potential partners limits an ego's ability to form new ties. Additionally, establishing new ties involves reaching out and communicating with these new and unknown partners, which requires both time and motivation. Decaying ties is also not easy. For example, egos may feel comfortable with their current ties and experience structural inertia that deter tie decay. Further, maintaining existing ties may have other advantages such as lower startup costs, greater certainty, and higher trust (Dahlander & McFarland, 2013). Therefore, low value ties may not be decayed even though new ties may provide better information. Despite the apparent differences between tie formation and tie decay, the literature has rarely studied the latter

especially in the context of teams and knowledge work (Dahlander & McFarland, 2013).

Team Boundaries and Networks

Contemporary organizations are being designed around teams that potentially shape one's network. Teams give their members their identity and foster interdependence among members (Alderfer, 1971). Both of these factors amplify the value of team membership and bring greater attention to team members. First, being part of a team triggers a sense of identity and belonging. For example, when they are placed in a team, both team members and outsiders recognize their team membership (Sherif & Sherif, 1969). This team identity sharpens the attention of the team members toward each other while affecting how team members interact with outsiders. Research has shown that greater attention is given to fellow members than to outsiders (Park, van Bavel, Hill, Williams & Thayer, 2016).

A second important feature of being in a team is the high degree of interdependence among team members (Van der Vegt, Emans, & Van de Vliert, 2001). Typically, team members are bound by reward systems that recognize the team as a whole. Individuals need input from other team members to complete their tasks (Campion, Papper, & Medsker, 1996). In this context, individual team members' targets and rewards are linked to and aligned with the team's targets and rewards, which keep the team members' efforts aligned with the team's efforts. The joint targets that individuals share with other team members help them understand each other's aspirations, and this facilitates a stronger team identity. Overall, the task and reward interdependence reinforce team identity. This identification also makes team members focus more on other team members. During these task-related activities, members observe whom their team members interact with. Members keep track of one another to ensure that everything is running smoothly and that they are following procedures correctly (Salas, Sims, & Burke, 2005).

Also, team members know that other members pay “close attention to what we are doing and will tell us if our behavior is appropriate or inappropriate” (O'Reilly & Chatman, 1996, p. 161). Team members understand and monitor each other's behaviors, thereby curtailing potential opportunistic actions (Barker, 1993). Therefore, compared to outsiders, team members are more likely to be monitored by their peers. However, some team members are monitored more than others. For example, individuals who are seen as different from the rest of the team are often under greater scrutiny (Robinson & O'Leary-Kelly, 1998). Given the importance of team boundaries, how do networks change, particularly in knowledge-intensive work?

Team Boundaries and Network Change

Integrating the literature on network change and team boundaries, we propose a more nuanced approach to network changes in the context of KS networks. Recall that network change involves tie formation and decay, whereas team boundaries suggest that network changes are different within and outside teams. Combining the notions of tie formation/tie decay with proximal/distal ties (i.e., within team ties vs. outside team ties) in the context of KS networks, we propose four individual KS network evolution (KSNE) actions: (a) proximal tie formation (Panel A in Figure 1), (b) proximal tie decay (Panel B in Figure 1), (c) distal tie formation (Panel C in Figure 1), and (d) distal tie decay (Panel D in Figure 1). We study network change in the context of KS ties but not knowledge-giving or knowledge-contributing ties because individuals who must successfully complete an instrumental task need to seek new or updated knowledge. Figure 1 shows the four possible KSNE actions.

---Insert Figure 1 here---

Both endogenous and exogenous factors drive social network changes (Ahuja et al., 2012; Contractor, Wasserman, & Faust, 2006). However, the two network changes of tie

formation and tie decay are distinct and occur for different reasons (Koka et al., 2006). Kleinbaum (2018) points out that tie formation is based on the opportunities in which an individual gets to interact with others, whereas tie decay is an individual choice. Empirical studies of individual network change have incorporated both personality (e.g., big five personality traits) and prior network characteristics (e.g., reciprocity) as predictors or control variables (Parise & Rollag, 2010; Vissa & Bhagavatula, 2012). We focus on one of the most-studied network positions, brokerage, to investigate whether and how brokerage drives network change. Although brokerage has been well studied in social network literature, it has primarily been studied as an antecedent to performance. We suggest that brokerage is also an important antecedent to network change, within and outside the team, even after controlling for exogenous factors of personality and task characteristics (Salancik, 1995).

Brokerage and Network Change

We build on Burt's (1992) insights about brokerage along with Gould and Fernandez's (1989) work that identifies different brokerage types based on group membership. Individuals who occupy brokerage positions bridge unconnected parties. Burt (1992) defines a broker as "a person who generates profit from being between others" and who plays on the "conflicting demands and preference against one another and builds value from their disunion" (p. 34). Non-brokers, or those low in brokerage positions, have alters who are connected to each other (like in cliques). Timely access to information is one of the key benefits that brokers accrue from their position (Burt, 1992; Clement, Shipilov, & Galunic, in press). Moreover, because of their advantageous network positions, brokers are able to get non-overlapping and private information from their multiple network connections. This information is also often rare at the time brokers get access to it, and the brokers can use this private and rare information to advance their own

agenda. However, how do individuals get information from their alters? By seeking it out with specific questions and asking for advice and guidance—that is, they proactively seek out knowledge and information from others. Brokerage has always been about the flow of information from others to the broker that brokers can then selectively share with whomever they wish. In other words, brokerage has always been about the directional flow of information and knowledge from the alters to the ego even though it may have not been so explicitly stated in the literature. In the context of brokerage, we bring the notion of directional flow of knowledge to the forefront by conceptualizing the role of intra- and inter-team brokers in a KS context.

Brokers' network positions also give them great autonomy. Whether they exercise this autonomy for their own benefit or for the benefit of the collective has been debated (Obstfeld, 2005). However, Xiao and Tsui (2007) argue that the self-serving orientation of brokers drives their behavior and that brokers are “fulfilling self-interest rather than accommodating social norms and obligations” (p. 4). They also propose that brokerage involves valuing the self over the collective. That is, brokerage is used primarily for self-gain and not for the collective good. Despite this lack of clarity about brokers' motivations, the benefits of brokerage flowing from greater autonomy have been well documented. A recent meta-analysis (Fang et al., 2015) found that brokers do get ahead. Not only does their position get them performance advantages, but brokers also develop a reputation among others (Grippa & Gloor; 2009).

However, being a broker is complex and it makes significant cognitive demands. Brokers consume more cognitive resources for the same key reason they get ahead: effort in “decoding and encoding information” (Burt & Merluzzi, 2016, p. 369). Because brokers sit in between the two unconnected alters, they receive different bits of information from different sources. Burt and Merluzzi (2016) point out that brokers need to understand these diverse bits of information

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and then recombine them in new and acceptable ways for other alters. All this involves additional cognitive effort that non-brokers do not have to expend. Non-brokers have alters who are connected to each other; therefore, they share familiar information that is easier to process.

So how do the autonomy that brokers enjoy, the additional monitoring they face within their teams, and the additional cognitive resources they expend translate into network changes that they can initiate? For any individual and not just brokers, developing and maintaining ties demand intensive resources and consume time, especially when these ties create a “forbidden triad,” that is, ties among alters who are not connected to each other (Granovetter, 1973, p. 1363). Therefore, brokers’ most optimal strategy may be to avoid expanding their network indiscriminately to maximize diverse information (Mehra, Kilduff, & Brass, 2001). They might continually evaluate the quality of alters’ information and dissolve ties that provide redundant information. They can then form new ties for novel information.

The above argument, however, assumes that brokers are not constrained by memberships in social groups and can behave as autonomous agents who seek opportunities to exploit. However, in most organizations, as in our study, individuals are embedded within teams. As discussed above, there is a higher level of monitoring of individuals by their own team members than by outsiders because of team identity and interdependence among team members (Sherif & Sherif, 1969; Van der Vegt et al., 2001). This monitoring is even higher for brokers who stand out among team members (Grippa & Gloor, 2009). As a result, brokers may be somewhat constrained in the level of autonomy they can exercise within a team in their network change actions. We develop these ideas more in the following section.

Brokerage Location and Team Boundaries: Intra-Team and Inter-Team Brokers

Network researchers have identified different types of brokers based on social boundaries

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(Gould & Fernandez, 1989). Given that employees can be members of a team and a larger organization simultaneously, they can be brokers in two different places: inside the team (intra-team brokers) and outside the team (inter-team brokers). Intra-team brokers connect their own team members who are not connected to one another. They generate value by coordinating with other team members (Gould & Fernandez, 1989; see Figure 1). However an individual can also have ties outside the team and, in the process, bridge two unconnected alters who are outside their team (inter-team brokers). Inter-team brokers act as liaisons (Gould & Fernandez, 1989) connecting different groups. Despite this, there are situations when a broker has an alter inside the team and an alter outside the team (Gould & Fernandez, 1989). We consider this part of inter-team brokerage because there is access to information outside the team. The overall advantage of inter-team brokerage is that these brokers have access to diverse information from these different sources. Below, we highlight the key differences between intra-team and inter-team brokerage while recognizing the possibility that an individual can be both simultaneously.

Intra-team brokerage. We propose that when individuals bridge unconnected members in small-group settings, alters and others tend to observe and monitor them more, offsetting the advantage of autonomy in brokerage. As mentioned earlier, because of team identity and task interdependence, members observe and monitor each other (Barker, 1993; Garrahan & Stewart, 1992; Sewell, 1998). Besides the overall monitoring of team members by other team members, intra-team brokers get additional monitoring because they stand out from the rest of the team. Because they are easily recognizable given their network position within their team, intra-team brokers face greater scrutiny from other team members. Further, other team members may also label them as being corrupt and self-centered and accuse them of not being team players because of their self-serving nature (Stovel & Shaw, 2012; Xiao & Tsui, 2007). This labeling may trigger

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even further monitoring. Therefore, intra-team brokers tend to be monitored for their various activities, including their networking activities, and may thereby become constrained in their network change actions.

Inter-team brokerage. Inter-team brokerage is closer to the original conceptualization of brokers as autonomous agents. Inter-team brokers have alters outside their team, and thus they can bridge between these external alters or be the go-between for external alters and alters inside the team. Alters outside the primary team of the inter-team broker may all belong to a single team other than the broker's own team, or they may belong to different teams. In contrast to intra-team brokers, whose alters are exclusively inside the broker's team and are thus extensively monitored by their alters, inter-team brokers experience less monitoring, especially when the alters are spread across different teams, partly because of a lack of interdependence between inter-team brokers and their alters and partly because inter-team brokers interact less frequently with outside alters. Overall, external alters of inter-team brokers have fewer opportunities to observe and monitor the broker.

In summary, team boundaries impose constraints on intra-team brokers that inter-team brokers do not face and therefore influence where and when brokers can exercise their free will and where and when they are curtailed in shaping their networks. Although both intra-team and inter-team brokers are more strongly affiliated with and focused on their own teams because of the different constraints they face inside and outside their teams, there are variations of how they are able to form and decay their proximal and distal ties within and outside their teams. We explain these processes below.

Hypotheses

Intra-Team Brokerage and Proximal Tie Formation

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An intra-team broker connects team members who do not have ties to each other and can establish a new proximal tie within the team (see Panel A in Figure 1) in two different ways. First, the broker can add a new contact who has no connections to the broker's prior alters. To seek knowledge from a new contact, brokers will need to decode the information provided by this new alter. This decoded information would then need to be translated when exchanging information with other team members (Cross & Parker, 2004). This cognitive process is demanding, and it occurs in the context of intense team interactions and monitoring. Thus, intra-team brokers are not likely to add new proximal alters who are unconnected to existing alters within their team.

The second way intra-team brokers can establish within-team ties is by adding new proximal alters who are already connected to the current alters within the broker's team. However, there is no additional informational benefit because the knowledge is already available via the current contacts. Further, in such a situation, the broker will be monitored by all intra-team alters who are already tied to each other. Consequently, the broker has little incentive to add new ties to connected alters within the team. Overall, because of cognitive burden, lack of new information, and monitoring, an intra-team broker is not likely to add new ties within the team. In contrast, individuals who are tied to other team members that are also tied to each other, i.e., individuals in low intra-team brokerage positions, are monitored less by remaining team members and can potentially gain new information by adding new ties. Thus,

H1. Individuals' intra-team brokerage will be negatively associated with proximal KS tie formation.

Intra-Team Brokerage and Proximal Tie Decay

Just as intra-team brokerage shapes the addition of within-team ties, it also influences

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brokers' tendencies to decay within-team ties. Tie dissolution, or tie decay, occurs when a person dissolves ties with erstwhile alters (see Panel B in Figure 1). Generally, dissolving ties can be stressful; this signals that focal individuals devalue their former alters (Leary & Springer, 2001; MacDonald & Leary, 2005). For this reason, intra-team brokers face an especially complex situation because they are already being monitored within their teams. These brokers have alters within their teams who are not connected to one another and are part of a "forbidden triad" (Granovetter, 1973). To reduce stress, intra-team brokers have two options: they can hope for network closure when the two unconnected parties within their teams eventually establish a direct tie, or they may decay ties to one alter and thus take sides. Both of these options mean that the brokers lose their structural advantage. Brokers really have no control over the first option because the initiative is with the alters to seek ties with these unconnected members. In contrast, brokers can control the second option; they can drop one of the proximal alters and take sides with the other, thereby reducing their own stress. However, they may also lose access to diverse information. Thus, intra-team brokers are likely to decay proximal ties in order to reduce the additional brokerage burden that arises from additional monitoring within their teams. However, as mentioned earlier, those in low intra-team brokerage positions do not experience cognitive burden or the stress of being an intermediary. Further, they are part of dense networks where members are connected to each other and there is no pressure to drop ties. In fact, for low intra-team brokers, there would be greater pressure to retain their existing ties. Thus,

H2. Individuals' intra-team brokerage will be positively associated with proximal KS tie decay.

The constraints that come with intra-team brokerage also limit the intra-team broker's networking behaviors outside the team. An intra-team broker invests a non-trivial amount of time

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and effort to coordinate and facilitate direct KS ties with unconnected team members. These intra-team coordination actions and the pressure of being monitored substantially drain the broker's cognitive resources such that the intra-team broker takes the path of least resistance to manage outside networks.

Intra-Team Brokerage and Distal Tie Formation

We suggest that intra-team brokers limit their KS actions outside their team for different reasons. First, establishing new ties requires time and resources, especially if these ties are outside the team (Dahlander & McFarland, 2013). Prior research has shown that individuals are less likely to exert the effort needed to form ties with members of other units (Feld, 1981). Second, individuals in different teams may have different values and even divergent ways of looking at problems, so establishing ties and acquiring actionable information from them requires extensive work (Hansen, 1999). Third, individuals may be unsure about the quality of information distant alters might provide (Dahlander & McFarland, 2013). Facing uncertainty and limited time and cognitive resources to expend, intra-team brokers may not form new distal KS ties outside their teams. In contrast, individuals who are tied to other team members that are in turn tied to each other, i.e., individuals in low intra-team brokerage positions, may have the necessary cognitive resources to establish ties outside their teams and value the comparatively unique information they get from these external ties. Thus, individuals who are in low intra-team brokerage positions could access unique information by adding new ties outside the team. Consequently, when compared to individuals who are low on intra-team brokerage, intra-team brokers are not likely to form distal ties outside their teams. Thus,

H3. Individuals' intra-team brokerage will be negatively associated with distal KS tie formation.

Intra-Team Brokerage and Distal Tie Decay

As discussed, intra-team brokers face within-team monitoring. Having limited abilities to act on their network positions within their teams and experiencing cognitive burden by bridging unconnected team members, their outside-team network actions may also be limited. In contrast, low intra-team brokers have greater autonomy to make network changes outside their team. However, distal ties do provide needed unique information. Thus, intra-team brokers need distal ties to access unique information that will help them (Ancona & Caldwell, 1992). Considering that the cost of establishing new ties is higher than the cost of maintaining existing ones, it is more economical to retain established distal ties than to form new distal ties (Dahlander & McFarland, 2013). Given that intra-team brokers have only limited residual cognitive resources after expending them on intra-team ties, their need for unique information, and the economics of tie maintenance, they are less likely to decay their distal ties. Low-intra team brokers also need unique information, but they are less constrained to drop ties because they are monitored less. Thus,

H4. Individuals' intra-team brokerage will be negatively associated with distal KS tie decay.

In sum, intra-team brokers are limited by their team context (not their structural opportunities) to act opportunistically in shaping their networks inside and outside their teams. However, inter-team brokers do not face the same monitoring as intra-team brokers. In the following section, we hypothesize the implications of this for network changes.

Inter-team Brokerage and Proximal Tie Formation

Inter-team brokerage differs from intra-team brokerage in that the alters are unable to monitor the inter-team broker. When brokers connect with alters who do not meet or work with

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them regularly, alters have little information to evaluate the broker. Further, when the broker's alters are dispersed across different teams, they are even less likely to monitor the broker. Note that an inter-team broker is monitored more when some of the alters are in the same team (including the broker's own team). However, such brokers still experience a lower level of monitoring from their alters than do intra-team brokers, who face a much higher degree of surveillance from their alters who are all in the same team. Thus, inter-team brokerage is the prototype that Burt (1992) proposed when discussing the greater autonomy that brokers have to act opportunistically. In contrast, individuals low on inter-team brokerage either have very few ties outside their team, or their external alters are connected to each other and can thus monitor the focal individual's opportunistic behaviors.

However, as a broker in the external network, the inter-team broker is free to act in both socially desirable and instrumental ways. High inter-team brokers, when compared to low-inter-team brokers, can act as information gatekeepers (Gould & Fernandez, 1989) who gain information from their outside network ties and then convey it to their teams. Coming from different parts of the external network, this information is diverse and rich. However, this information must be translated and customized if it is to serve the focal individual and the team, and for that, brokers need the help of their own team members. That is, the cognitive burden that involves synthesizing diverse information remains a factor even for inter-team brokers. However, because inter-team brokers are not under scrutiny by their teams, their greater autonomy allows them to form new proximal ties within their teams. Thus,

H5. Individuals' inter-team brokerage will be positively associated with proximal KS tie formation.

Inter-Team Brokerage and Proximal Tie Decay

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Inter-team brokers are also less likely to decay within-team ties for the same reason that they are more likely to add within-team ties. While intra-team brokers stand out within their own teams, inter-team brokers do not because their brokerage position and attendant behaviors lie outside their teams. As a result, inter-team brokers are considered regular team members within their own teams. Further, if they behave opportunistically by decaying their proximal ties, they may draw undue attention to themselves and be seen as selfish and not as team players. More important, inter-team brokers have no reason to decay their proximal ties. Maintaining their current proximal ties may provide the advantage of integrating external information with team information in a more economical manner as compared to forming new proximal ties, as discussed above. Even if inter-team brokers get some redundant information from within their teams, the cost of maintaining existing within-team ties is relatively low. Further, their source of unique information is based primarily outside, not inside, the team. Therefore, individuals who are high on inter-team brokerage, unlike those in low brokerage positions outside the team, are not likely to drop ties for social desirability and information integration reasons. Thus,

H6. Individuals' inter-team brokerage will be negatively associated with proximal KS tie decay.

Inter-Team Brokerage and Distal Tie Formation

Because they have access to external networks (outside the team), high inter-team brokers can more easily form distal KS ties with nodes outside their teams than can low inter-team brokers. These external nodes can be social isolates unconnected to the broker or to anyone in the network. Alternatively, they can be outsiders that have their own connections but not to the broker. Thus, in an external network, which is typically larger than a team, tie availability is not a limitation for brokers because they have a large pool of potential alters for establishing new KS

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ties. Furthermore, inter-team brokers have the freedom to change their networks because their alters in other teams are not monitoring their opportunistic networking behaviors. Driven by their need for unique information from outside their teams, a higher degree of tie availability, and their greater autonomy in the external network, individuals in such brokerage positions are likely to form newer distal KS ties than individuals with low inter-team brokerage positions. Therefore,

H7. Individuals' inter-team brokerage will be positively associated with distal KS tie formation.

Inter-Team Brokerage and Distal Tie Decay

Just as inter-team brokers are out of the spotlight and can easily add ties (Herman, 1982; Sewell, 1998), they can also decay ties, whether because of redundant information or because of the lack of pressure to retain ties. Maintaining ties involves spending valuable time and resources. Thus, distal KS ties that fail to provide pertinent and unique value drain time and resources. Thus, distal KS ties that fail to provide pertinent and unique value drain time and resources can be decayed by such brokers. By pruning redundant distal KS ties, inter-team brokers can more fully exploit the remaining KS ties and also free up their resources to seek new and more useful KS ties. Inter-team brokers are uniquely positioned to decay former ties in their distal KS networks because they have greater autonomy. In contrast, alters tend to monitor individuals with low brokerage even in external networks. By decaying ties, low-brokerage individuals may create dissonance in their networks. Consequently, individuals with low brokerage are under pressure to maintain and not decay their ties (Heider, 1958). Thus, inter-team brokers are expected to decay more distal KS ties to free up valuable resources as compared to individuals in low inter-team brokerage positions. Therefore,

H8. Individuals' inter-team brokerage will be positively associated with distal KS tie decay.

Method

Participants and Procedures

We conducted our study at a business school of a state university in the northeast United States. The participants were upper-level undergraduate students enrolled in two large course sections, one offered in the United States and the other in Singapore. The two sections had the same instructor¹ and used the same syllabus. Participation was voluntary; students received extra credit for participating in the study or by completing an alternative assignment. At the beginning of the semester, the instructor randomly assigned students to one of 121 software-project teams, each consisting of four or five students. Each team had to find a real-world organizational problem for its project. The teams had to work as information technology consultants to create a software system that addressed a specific business problem. Students had sufficient interaction for around three months within and outside their teams so that each student could develop a KS network. Weekly mandatory sessions were scheduled for the teams to work on their projects, and this further facilitated the development and evolution of individual KS networks.

Data were collected in two waves. Students were surveyed using an online survey in both waves, and the course instructor provided archival data for use as control variables. Students completed the wave-1 survey five weeks into the semester (T1). The survey included questions about KS and friendship networks and individual-level control variables, including self-monitoring personality, perceived task complexity,² and demographic variables. During the four weeks after the wave-1 survey (T2), participants again reported their KS network. Data about midterm feedback (on the team project) were generated between T1 and T2 and collected from

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¹ The course instructor was not an author on this paper.

² Team members had enough exposure five weeks into the semester at T1, the time of wave-1 measurement, to be able to form opinions about the complexity of the project task.

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the instructor at the end of the semester. The first survey wave had 408 participants (the response rate was 70.22%), and the second had 399 participants (the response rate was 68.68%); 372 students completed both survey waves. In T1, there were 102 groups (84.30%) in which the participation rate was equal to or higher than 50%; in T2, there were 98 groups (80.93%) in which the participation rate was equal to or higher than 50%. We first excluded 33 respondents who completed less than 70% of survey items. We then removed 18 teams in which participation was less than 50% (Kossinets, 2006). Participation rate in each wave was more than 75% for the included teams. To ensure that nonparticipation did not skew our results, we conducted ANOVA to compare early and late respondents and found no significant differences for any of the four KSNE actions, the two predictors, or the control variables. We used late respondents as a proxy for nonrespondents because KSNE data were not available for nonrespondents.³ The final analysis included 302 respondents from 97 teams.

Measures

KSNE variables. Individual KS networks were measured using the roster method. At both T1 and T2, we instructed participants as follows: “Please look carefully down the list and place a check next to the names of people from whom you acquired some new knowledge related to your class team project,” following prior approaches (e.g. Hansen, 1999). Our approach to conceptualizing and measuring KS networks is also in line with prior research (e.g., Podolny and Baron, 1997; Landis, Kilduff, Menges, & Kilduff, 2018).

From the survey data, we created four sociomatrices, one each for the U.S. and Singapore sections, and one each for T1 and T2, to capture individual-level asymmetric KS network data. In each matrix, cell X_{ij} represented i 's KS tie to j as indicated by i and was coded as 1 for the

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³ Further details of our data cleaning procedures are available on request.

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presence of a tie and 0 otherwise. The data were asymmetric: *i* could seek knowledge from *j*, but *j* did not necessarily seek knowledge from *i* (e.g., Hansen, 1999). These four matrices were used to develop all KS-related measures. Based on the team membership data provided by the instructor, we split an individual's ego network into two different sub-networks: within-team ego network and outside-team ego network. Proximal tie formation captures the number of new within-team ties that ego had at time T2 that did not exist at T1. Proximal tie decay captures the number of existing within-team ties that ego had at time T1 that were no longer ties at T2. Distal tie formation captures the number of new ties that ego had from outside his or her team at T2 but that did not exist at T1. Distal tie decay captures the number of existing outside-team ties that ego had at time T1 but that no longer existed at T2. See Figure 1 for an illustration.

Independent variables. Intra-team and inter-team brokerage were measured by counting the number of structural holes spanned by individuals within their team network and outside their team network at T1, respectively (Borgatti, Everett, & Johnson, 2013). A structural hole is the lack of ties between two people who are both ego's contacts. The number of structural holes an ego has is the number of pairs of contacts who are not connected to each other. Intra-team brokerage was thus measured by counting the number of structural holes spanned by an ego in his or her team by considering *only* alters within the ego's team. At the same time, inter-team brokerage had two parts: first, the number of structural holes spanned with both alters outside the broker's team, and second, the structural holes where one alter was inside the broker's team and the other alter was outside. It is important to note that the structural holes spanned by an ego that were solely within his or her team were excluded in the calculation of inter-team brokerage. Thus, if the ego did not have any alter outside his or her team, his or her inter-team brokerage would be zero. It is a standard practice in network research to standardize or normalize network

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measures to control for network size differences (Borgatti, 2005; Wasserman & Faust, 1995). We normalized structural holes' measures with individuals' KS network sizes at T1 (Barabási & Albert, 1999; Price de Solla, 1976) by dividing the two brokerage measures discussed above with individuals' total KS outdegree centrality. We used the total KS outdegree of individuals rather than their intra- and inter-team KS outdegree to normalize because we wanted the two brokerage measures to be comparable so we could obtain their relative effects on the four KSNE actions.

Control variables: Individual level. We accounted for several alternative explanations that encompassed individual differences, their knowledge networks, and their friendship networks. At the individual level, we first accounted for individual differences by controlling for self-monitoring (one of the most studied network-oriented personalities) with an 18-item scale (Gangestad & Snyder, 2000). Sasovova et al. (2010) found that over time, a high self-monitor tends to create and drop friendship ties suggesting that high self-monitors tend to be more active in changing their networks. One example item of self-monitoring includes the following: "I have trouble changing my behavior to suit different people and different situations." We used the sum of true (1) and false (0) values (after reverse coding items appropriately) to represent the extent of self-monitoring. The composite reliability for this scale was 0.80.

We also controlled for demographic variables, including age, class standing (1 = sophomore, 2 = freshman, 3 = junior, 4 = senior), gender (1 = male, 0 = female), and race (Brands & Kilduff, 2014). Among the 302 students, 53.6% were Caucasians, and 38.7% were Asians. Therefore, we created two dummy variables as control variables: Caucasians (1=Caucasians, 0 = others) and Asians (1=Asians, 0 = others).

The nature of social networks and their importance to teams is contingent on the tasks that the team is engaged in (Hansen 1999). Specifically, complex tasks may increase an

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individual's needs for new information and knowledge in the context of team-based project work (Maznevski & Chudoba, 2000). Therefore, we controlled for task complexity, measured as an average score from a widely used five-point Likert-type scale containing eight items (Haerem & Rau, 2007). One example item was, "To what extent do you feel that your solutions were vague and difficult to anticipate?" In our study, the composite reliability for this scale was 0.85.

We controlled for KS reciprocity at T1 (because reciprocated ties are stronger ties) to account for the influence of prior strong ties (Ahuja et al., 2012; Schulte et al., 2012). Prior research has suggested that strong ties with others come with pressure to retain those ties (Kleinbaum, 2018). A reciprocated KS tie occurs when both parties in a tie report seeking knowledge from each other. Reciprocity was calculated as the ratio of reciprocated ties of ego to his or her total ties in the network.

Further, while friendship ties are affect laden, they provide information (e.g., Balkundi & Harrison, 2006). Therefore, we need to rule out friendship ties because KS ties can be formed or decayed by egos depending on their friendship ties. Therefore, we control for out-degree and betweenness centrality of an ego's friendship network because they are the two most potent network positions (Fang et al., 2015). Friendship network was measured at T1 by using the roster method. We separated the overall friendship network outdegree into intra- and inter-team friendship outdegree at T1. We calculated the friendship betweenness centrality of each actor using the formula suggested by Freeman (1978, p. 221). The betweenness of an actor is, therefore, a measure of the number of times an actor occurs on a geodesic within the friendship network. Because the formula includes the network size, the raw values for betweenness can be large when the network is large. All network measures were calculated using UCINET 6. The definitions and calculations of key network variables are summarized in Table 1.

---Insert Table 1 here---

Control variables: Team level. Because our data were nested in teams, we controlled for four team-level constructs that accounted for team-level network properties, team transactive memory, team-level project feedback, and country.

Teams with dense networks may limit the opportunities for individual team members to change their networks because there are few to no available unconnected members. In contrast, sparse networks (where only few members seek knowledge from each other) are conducive for tie formation for intra-team brokers because there are many potential network partners available (e.g., Obstfeld, 2005). Thus, we controlled for network density (Wasserman & Faust, 1995).

Network change may also be influenced by team emergent states (Schulte et al., 2012). Prior research has stated that it is important for team members to locate individuals who possess the required knowledge and then intentionally acquire appropriate knowledge from them (i.e., team transactive memory; Lewis, 2004). Even so, a shared understanding among team members about the expertise within the team may impact the changes that a broker may make. Prior research has explored this connection between network changes and TMS (Lee, Bachrach, & Lewis, 2014; Yuan, Fulk, Monge & Contractor, 2010). We controlled for TMS by using a well-established scale and collected data at the individual level (Lewis, 2003). The scale was reliable with a composite reliability value of 0.77. Since there is no appropriate theory to justify the theoretical distribution of the within-group ratings for TMS, we calculated $r_{wg(j)}$ with three possible models (James, Demaree, & Wolf, 1984; LeBreton & Senter, 2008). The mean $r_{wg(j)}$ was .79, .81, .89, respectively, for uniform null, slightly skewed, and moderately skewed models. $R_{wg(j)}$ ranged between 0.75 to 1 with regard to all three models. Additionally, the F value showed the between-team difference to be significant ($F = 1.31, p = .035$). The intraclass correlations for

this scale were 0.06 for ICC(1) and 0.24 for ICC(2). These analyses thereby provided support for the aggregation of individual ratings on this scale to the team level.

Research has shown that prior team performance may change how team members relate to other team members (Mullen & Copper, 1994). Therefore, we controlled for the instructor's midterm feedback on team projects given to the teams between time T1 and T2.

Because our sample was from two different countries, we controlled for campus location because of potential cultural differences between the U.S. and Singapore teams that might cause differences in individuals' KS network dynamics. In Singapore, where collectivism is more prevalent (Hofstede, 1980), individuals may feel more pressure to not drop an existing tie. A complete listing of items for multi-item variables is provided in Appendix A.

Results

Because individuals in our sample are nested within teams, we used the hierarchical linear modeling (HLM) procedures suggested by Bryk and Raudenbush (2002) with the HLM 6.0 statistical software. We first checked whether team-level differences existed in the four KSNE variables using the null model in hierarchical linear models. This analysis yielded nonsignificant variance of three KSNE variables across teams ($\chi^2 = 88.94, p > .05, ICC = .003$ for proximal tie formation; $\chi^2 = 84.71, p > .50, ICC = .001$ for proximal tie decay; $\chi^2 = 107.62, p = .20, ICC = .05$ for distal tie formation) but indicated significant differences among teams with respect to distal tie decay ($\chi^2 = 160.69, p = .00, ICC = .16$). To be consistent for all the network change models, we report the HLM results (e.g., Lau & Liden, 2008).

Table 2 shows the means,⁴ standard deviations, and correlations for all the variables. In Table 3, we show the results of HLM analyses for proximal network change actions. In Table 4,

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⁴ *It is notable that the mean and standard deviation of friendship betweenness centrality are large (mean = 439.00, SD = 895.08) because the calculation of betweenness centrality incorporates network size.*

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we show the results of HLM analyses for distal network changes. We discuss the results in the following paragraphs, focusing first on intra-team brokerage and then on inter-team brokerage. We report both the standard errors (SE) and actual p -values in the table and use an alpha level of .05 for all statistical tests.

---Insert Tables 2, 3, and 4 here---

H1 stated that intra-team brokerage would be negatively associated with proximal KS tie formation. The results indicated that intra-team brokerage was negatively and significantly related to proximal tie formation ($\gamma = -.26, p = .00$; see Model 2, Table 3). H2 proposed a positive relationship between intra-team brokerage and proximal tie decay. This hypothesis was supported because intra-team brokerage was significantly associated with proximal tie decay ($\gamma = .26, p = .02$; see Model 4, Table 3).

H3 and H4 specified the relationship between intra-team brokerage and individuals' distal KSNE actions. H3 predicted that intra-team brokerage is negatively associated with distal tie formation. The results indicated that this hypothesis was not supported ($\gamma = -.09, p = .42$; see Model 6, Table 4). H4 proposed a negative relationship between intra-team brokerage and distal tie decay. The results indicated that intra-team brokerage was negatively associated with distal tie decay ($\gamma = -.52, p = .00$; see Model 8, Table 4). Therefore, H4 was supported. Thus, regarding the impact of intra-team brokerage on the four KSNE actions, three hypotheses (H1, H2, and H4) were supported, and one (H3) was not.

The next set of hypotheses focused on brokerage outside the team. H5 proposed a positive relationship between inter-team brokerage and proximal tie formation. The results in Table 3 confirmed this relationship: inter-team brokerage had a positive and significant impact on proximal tie formation ($\gamma = .02, p = .04$; see Model 2, Table 3). H6 posited a negative

relationship between inter-team brokerage and proximal tie decay. This hypothesis was rejected ($\gamma = -.03$, $p = .06$; see Model 4, Table 3). Thus, our results partially support the hypotheses related to the impacts of inter-team brokerage on proximal tie changes.

Hypotheses H7 and H8 proposed a positive association between inter-team brokerage and distal KSNE actions, respectively. The results do not support H7: inter-team brokerage was not related to distal tie formation ($\gamma = -.01$, $p = .52$; see Model 6, Table 4). However, the results indicated that inter-team brokerage was positively associated with distal tie decay ($\gamma = .09$, $p = .00$; see Model 8, Table 4). Therefore, H8 was supported. Overall, our results supported two of the four hypotheses related to the impacts of inter-team brokerage on individual KSNE actions and marginally supported one association.

In summary, we find that intra-team brokers add fewer ties, drop more ties in their teams, and drop fewer ties outside their teams. The results for intra-team brokers with respect to forming outside-team ties were not significant. Overall, intra-team brokers seem to prefer maintaining the status quo. In contrast, inter-team brokers seem to be more active in shaping their networks. They tend to add more ties inside their teams but are less likely to decay ties inside their teams and instead will decay ties outside their teams.

Discussion

Theoretical Contributions

The current study extends our understanding of social networks, particularly that of social network evolution, as we highlight the importance of team boundaries in shaping social networks. Salancik (1995) raised the question about where ties come from. We sought to answer this question along with exploring how ties decay in the context of team boundaries because both these changes can occur both inside as well as outside an individual's team. After taking a host of

alternative explanations into account, such as personality, task complexity, strength of ties, and even team-level effects, we find that individuals shape their networks based on their brokerage positions inside and outside their team.

Our paper also improves our understanding of brokers and the direction of flow of information during brokerage. Recently, Li, Li, Guo, Li and Harris (in press) have made a case for why giving advice (unlike seeking advice or KS) may include informational benefits for the advice-giving broker. However, many of these benefits depend on how the receivers of knowledge use that information. We focus on the primary receiver of information—the one who actively seeks out knowledge from his or her connections. For such brokers, the benefits of seeking out knowledge are direct and immediate, and the action is more in line with the actual mechanisms that Burt (1992) and others have proposed. By seeking out knowledge from different sources, brokers are able to combine the information to make more unconventional decisions (and thus be creative). They can also act as intermediaries in deciding what information to convey to their contacts and whether to even mention their contacts to each other. This would be the first step in deciding whether brokers want to get their contacts directly connected or keep them apart. Underlying the structural holes theory is the key assumption that brokers seek out information rather than being mere providers of it. That is, the dominant assumption and measurement of brokerage in instrumental ties such as advice tend to be outgoing ties with inflowing information. We emphasize this so that future research can build on the direction of ties and their role in arbitrage.

Further, our findings about the two types of brokerage contribute to the debate on the contexts in which structural holes are a disadvantage. Although researchers have overwhelmingly focused on the benefits of structural holes, they have identified two brokerage situations that can

limit brokers: having strong ties and being in collective cultures (Krackhardt, 1998, Xiao & Tsui, 2007). We add a new boundary condition for structural holes by proposing that when individuals work in team settings, they are observed by other team members, especially if they are brokers.

Team membership reduces opportunistic behaviors of individual members, particularly intra-team brokers. Our results show that compared to other team members, brokers refrain from their usual behaviors and are less willing to add ties to unconnected alters within their teams.

However, other members in less advantageous positions, that is, low in intra-team brokerage, are not constrained in their networking behavior inside their teams. That is, the team context serves as a boundary condition for the potency of brokerage.

Limitations and Future Research Directions

One of the limitations of the current study is that we do not directly measure mediating variables such as information exchanged, monitoring, and autonomy. Even though this is a common problem with network papers (e.g., Balkundi & Harrison, 2006), future research needs to unpack the mechanisms through which brokers use the information they receive from their alters to shape their networks. More fine-grained approaches such as grounded theory may be more appropriate in specifying these rich mechanisms and the deep interplay between structure and agency (e.g., Li et al., in press).

We used multi-wave research design with data from individuals nested in teams. We also tested for various boundary conditions and alternative explanations at the individual and team level, including the team's network structure and emergent state (team transactive memory). However, other personal factors that can potentially influence networks, such as the broker's general mental ability and prosocial motivation, need to be explored in the future.

The participants of this study can be seen as "temporary workers" because these students

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probably never worked together before and are not likely to be in the same work team again after the class ends. Therefore, the students may have acted in more instrumental ways because they knew that this overall network was temporary and that the changes they made were short-lived. Further research could analyze whether our findings still hold in situations where workers have known each other for a while and are expected to be in the organization for an extended period of time. Future research could also consider if there is a difference between the tie decay we observed in these temporary teams and the more long-term ties that become dormant over several years (e.g., Levin, Walter, & Murnighan, 2011). Regardless of the temporary or permanent nature of these teams, as long as performance orientation and interdependence remain the same in other contexts, we expect our findings to be externally valid. However, future research needs to explore whether our findings would hold where monitoring is uniformly high. For example, the level of monitoring in manufacturing teams tends to be quite high (e.g., Barker, 1993). Future research needs to explore how monitoring not just through informal relationships but also through electronic surveillance and other unobtrusive approaches changes social structures and affects intra-team brokerage accordingly.

We proposed eight hypotheses and found support for five of them. The hypotheses that were not supported involved distal tie formation as the dependent variable and the two types of brokerage—intra-team and inter-team brokerage—as predictors, respectively. It could be possible that both types of brokers find that the cost benefit equation does not yield net benefits to them when forming new KS ties with people to seek useful and unique information. The benefits of connecting with external sources of information are clear for both types of brokers because external alters who are not connected with the existing alters of the broker provide unique information that may be useful to both types of brokers in their team projects. However,

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there are two costs associated with forming new KS ties outside the team. First, brokers need to identify those people outside their teams who are not connected (or are less connected) with the existing alters of the broker to be able to receive unique and useful information from them.

Second, both types of brokers face the additional cognitive burden of processing and integrating new information that comes from outside the team with information they have gained from within their teams. The sum of these costs may cancel out or even outweigh the benefits to the brokers from the new, unique, and useful information they stand to gain from the new external alters. Future research needs to explore these potential costs and benefits to better understand how and when both types of brokers form new ties outside their teams.

Managerial Implications

Given the fast pace of knowledge generation and change in the knowledge society, individuals who fail to continually evaluate the value of their present and potential knowledge ties or fail to use that information to change their KS networks may fall behind others who are actively engaged in the learning and action cycle. The results of this study clearly provide evidence that individuals' KS network ties evolve both within and outside their team boundaries. Hence, individuals should change their KS ties depending on their dynamically changing knowledge needs and as they learn about the value of knowledge from their existing ties and nonconnected others. In this dynamic process, brokerage strongly predicts KSNE actions, and brokerage location impacts individual KSNE actions. Therefore, managers who want to encourage team members to seek knowledge and gain the benefits of enhanced knowledge from different contacts should help individuals identify their own brokerage position. Further, teams need to seek out members who may be peripheral inside the team but are in advantageous positions elsewhere. These identified outside-team brokers then need to be seen as resources that

can potentially help the team and other members in it.

Typical team building exercises focus on activities within the team to help develop cohesion (Cummings & Worley, 2014). The findings of this study have important implications for managers that seek ways to improve their team's chemistry. Too much emphasis on the team may make members more isolated from the workplace while making them watchful of each other. Not only would this make individuals more disenchanted with their own teams, but it would also distance them from the rest of the organization. Therefore, the implication of this study is that managers need to seek out requisite variety in their team members' networks so that they have an optimal number of ties inside and outside their teams.

Conclusion

We extend social network literature by providing a finer-grained analysis of network evolution in team contexts by partitioning network changes into four distinct elemental types. We tested how prior networks in terms of intra- and inter-team brokerage drive network change. We thus add new insights into the differential impacts of intra-team and inter-team brokerage to the literature on social network evolution. Overall, the findings of this study suggest that even individuals in powerful network positions are contained by their contexts.

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Figure 1. The conceptualization of individual KSNE actions.

Note. Each node represents a person. The blank nodes represent persons in the same team with the ego node. The gray nodes represent persons who are outside the team. The dashed circle indicates the team boundary. Directed ties from the ego to the nodes imply that the ego person sought knowledge from the nodes.

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Table 1

Definitions of The Key Network Variables

Variable	Definition	Calculation
Proximal tie formation	Within-team ties that were formed between T1 and T2.	The number of new within-team ego network ties that were formed between time T1 and T2.
Proximal tie decay	Within-team ties that decayed between T1 and T2.	The number of existing within-team ego network ties that were decayed between time T1 and T2.
Distal tie formation	Between-team ties that were formed between T1 and T2.	The number of outside-team ego network ties that were formed between time T1 and T2.
Distal tie decay	Between-team ties that decayed between T1 and T2.	The number of existing outside-team ego network ties that were decayed between time T1 and T2.
Overall brokerage	The degree to which an ego connects otherwise unconnected alters.	The number of structural holes spanned by an ego. A structural hole is the lack of a tie between two persons who are both contacts of the ego. Hence, the number of structural holes an ego has is the number of pairs of contacts who are not connected to each other.
Intra-team brokerage	The degree to which an ego connects otherwise unconnected alters inside his or her team.	The number of structural holes spanned by an ego inside his or her team considering only alters within the ego's team.
Inter-team brokerage	The degree to which an ego connects otherwise unconnected alters outside his or her team, at least one of whom is outside the ego's team.	Number of structural holes spanned by an ego outside his or her team considering at least one alter outside the ego's team. It is calculated by subtracting the number of structural holes spanned by the ego that lie solely within the team boundary from the total number of structural holes spanned by the ego in his or her entire network both inside and outside the team.
Outdegree centrality	The degree to which the ego is connected with others in the network.	The total number of outgoing ties reported by the ego.
Betweenness centrality	The degree to which the ego is able to control others.	How often the ego lies along the shortest path between two other actors.
Total network churn volume	The degree to which the ego's current ego network is different from his or her previous ego network.	The sum of: a) number of new ties formed by the ego between T1 and T2; and b) number of existing ties decayed by the ego between T1 and T2.

Note. In our analyses, we used the normalized intra and inter-brokerage that control for the influence of the total KS outdegree at T1. Normalized brokerage = raw brokerage measure at T1/total KS outdegree at T1.

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Table 2

Means, Standard Deviations, and Correlations Between the Variables

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Individual/Level-1 (<i>N</i> = 302)																							
1 Gender	0.49	0.50	—																				
2 Age	21.08	2.48	-.03	—																			
3 Caucasian	0.54	0.50	-.13	-.07	—																		
4 Asian	0.39	0.49	.17	.11	-.87	—																	
5 Class standing	3.11	0.64	-.01	.32	.13	-.14	—																
6 Self-monitoring	9.62	3.12	-.18	-.10	.08	-.07	-.06	(.80)															
7 Task complexity	2.06	0.54	-.05	-.06	-.17	.21	-.07	.01	(.85)														
8 KS reciprocity	0.40	0.29	.12	-.07	.02	.03	.04	-.07	-.12	—													
9 Friendship intra-team outdegree	0.53	1.01	.19	-.15	-.35	.36	-.24	.06	.08	.14	—												
10 Friendship inter-team outdegree	2.31	3.33	-.01	-.09	-.31	.30	-.22	.14	.09	.04	.16	—											
11 Friendship betweenness	439.00	895.08	-.02	-.08	.02	-.05	-.07	.12	.03	-.00	.01	.36	—										
12 Intra-team brokerage	0.94	0.88	-.05	.02	.13	-.17	.02	-.02	-.17	.05	-.05	-.14	.01	—									
13 Inter-team brokerage	5.43	6.36	.06	.03	-.21	.26	-.15	-.04	.15	-.04	.13	.30	.27	-.07	—								
14 Proximal tie formation	0.37	0.83	.00	.20	.08	-.06	.06	-.10	.14	-.13	.01	-.05	-.07	-.15	.12	—							
15 Proximal tie decay	1.09	1.37	-.02	-.05	-.05	-.03	-.07	.09	-.05	.04	-.10	-.02	.11	.21	-.11	-.26	—						
16 Distal tie formation	0.87	1.46	-.06	-.05	-.05	.05	-.19	.10	.05	.02	.02	.40	.25	-.02	.14	-.01	.09	—					
17 Distal tie decay	0.86	1.92	.04	.02	-.21	.26	.06	-.05	.12	-.27	.07	.20	.10	-.31	.41	.11	-.09	-.03	—				
Team/Level-2 (<i>N</i> = 97)																							
18 KS team density	0.53	0.20																		—			
19 Transactive memory system	3.57	0.35																		.08	(.77)		
20 Midterm feedback	4.41	0.96																		.11	.03	—	
21 Campus location	.80	0.40																		-.20	-.13	-.09	—

Note. Composite reliability estimates are in parentheses on the diagonal. Correlations between individual-level variables are significant at the .01 level when their absolute values > |.18| and significant at the .05 level when their absolute values > |.11|. Correlations between team-level variables are significant at the .05 level when their absolute values > |.19|. Two-tailed test.

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Table 3

HLM Results for the Effects of Brokerage on Proximal Tie Change Actions

	Proximal Tie Formation						Proximal Tie Decay					
	M1			M2			M3			M4		
	γ	SE	P	γ	SE	P	γ	SE	P	γ	SE	P
Intercept	.51	.23	.03	.60	.23	.01	1.47	.39	.00	1.34	.40	.00
<i>Level 1 Controls</i>												
Gender	-.01	.10	.91	-.04	.09	.69	.02	.16	.91	.05	.16	.76
Age	.09	.03	.00	.09	.03	.00	-.02	.04	.63	-.01	.04	.74
Caucasian	.27	.19	.15	.27	.18	.14	-1.01	.32	.00	-.98	.32	.00
Asian	-.03	.20	.89	-.10	.20	.61	-.71	.34	.04	-.59	.34	.09
Class standing	-.01	.11	.94	.03	.10	.78	-.08	.18	.68	-.12	.18	.49
Self-monitoring	-.05	.02	.01	-.04	.02	.02	.08	.03	.02	.07	.03	.03
Task complexity	.18	.10	.08	.12	.10	.23	-.08	.18	.67	-.01	.18	.98
KS reciprocity	-.30	.24	.20	-.12	.23	.63	.49	.40	.23	.30	.41	.46
Friend intra-team outdegree	.05	.08	.48	.09	.07	.24	-.17	.13	.18	-.21	.13	.10
Friend inter-team outdegree	.02	.02	.37	.01	.02	.73	-.06	.03	.07	-.05	.04	.17
Friend betweenness	-.00	.00	.09	-.00	.00	.05	.00	.00	.02	.00	.00	.01
<i>Level 2 Controls</i>												
KS team density	-.82	.25	.00	-.82	.24	.00	.57	.42	.18	.57	.42	.17
Transactive memory system	-.36	.14	.01	-.37	.13	.01	.05	.23	.83	.07	.23	.78
Midterm feedback	.04	.05	.41	.04	.05	.44	.13	.09	.14	.14	.09	.13
Campus location	-.30	.15	.05	-.36	.15	.02	.48	.26	.06	.56	.26	.03
<i>Level 1 Predictors</i>												
Intra-team brokerage				-.26	.06	.00				.26	.11	.02
Inter-team brokerage				.02	.01	.04				-.03	.02	.06
χ^2	79.01			84.18			81.34			83.51		
Deviance	760.25			750.42			1066.37			1065.62		

Note: Unstandardized estimates are reported. Two-tailed test. Individual $n = 302$; Team $n = 97$.

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Table 4

HLM Results for the Effects of Brokerage on Distal Tie Change Actions

	Distal Tie Formation						Distal Tie Decay					
	M5			M6			M7			M8		
	γ	<i>SE</i>	<i>P</i>	γ	<i>SE</i>	<i>P</i>	γ	<i>SE</i>	<i>P</i>	γ	<i>SE</i>	<i>P</i>
Intercept	1.41	.41	.00	1.36	.42	.00	-.07	.54	.89	.52	.52	.32
<i>Level 1 Controls</i>												
Gender	-.25	.17	.14	-.25	.17	.14	.12	.22	.58	.02	.20	.91
Age	.04	.04	.33	.04	.04	.31	-.09	.05	.11	-.10	.05	.03
Caucasian	.07	.32	.83	.11	.32	.74	.41	.42	.32	.23	.38	.56
Asian	-.04	.34	.91	.01	.35	.98	1.41	.45	.00	.88	.42	.04
Class standing	-.34	.18	.05	-.35	.18	.05	.11	.23	.62	.25	.20	.23
Self-monitoring	-.00	.03	.91	-.01	.03	.85	-.03	.04	.47	-.01	.04	.78
Task complexity	.06	.17	.71	.07	.18	.71	-.18	.22	.42	-.36	.20	.08
KS reciprocity	.28	.39	.48	.35	.40	.38	-1.97	.51	.00	-1.60	.46	.00
Friend intra-team outdegree	-.13	.13	.32	-.12	.13	.35	.02	.16	.91	.10	.15	.49
Friend inter-team outdegree	.16	.03	.00	.16	.04	.00	.09	.04	.05	.04	.04	.28
Friend betweenness	.00	.00	.06	.00	.00	.05	.00	.00	.76	-.00	.00	.73
<i>Level 2 Controls</i>												
KS team density	-.17	.48	.73	-.17	.48	.73	-1.34	.65	.04	-1.30	.67	.05
Transactive memory system	-.11	.27	.68	-.11	.27	.69	.04	.36	.90	-.04	.38	.92
Midterm feedback	.05	.10	.62	.05	.10	.61	-.29	.14	.03	-.34	.14	.02
Campus location	-.53	.28	.07	-.52	.29	.07	.15	.38	.70	-.15	.38	.69
<i>Level 1 Predictors</i>												
Intra-team brokerage				-.09	.11	.42				-.52	.13	.00
Inter-team brokerage				-.01	.02	.52				.09	.02	.00
χ^2	126.77*			126.34*			148.19**			191.51**		
<i>Deviance</i>	1080.63			1088.68			1231.73			1200.27		

Note: Unstandardized estimates are reported. Two-tailed test. Individual $n = 302$; Team $n = 97$.

Appendix A

Self-Monitoring (Gangestad & Snyder, 2000)

Instructions: Please circle either T (true) or F (false) to indicate whether the following statements are descriptive of you in general.

1. I find it hard to imitate the behavior of other people.
2. At parties and social gatherings, I do not attempt to do or say things that others will like.
3. I can only argue for ideas which I already believe.
4. I can make impromptu speeches even on topics about which I have almost no information. (Reversed)
5. I guess I put on a show to impress or entertain others. (Reversed)
6. I would probably make a good actor. (Reversed)
7. In a group of people I am rarely the center of attention.
8. In different situations and with different people, I often act like very different persons. (Reversed)
9. I am not particularly good at making other people like me.
10. I'm not always the person I appear to be. (Reversed)
11. I would not change my opinions (or the way I do things) in order to please someone or win their favor.
12. I have considered being an entertainer. (Reversed)
13. I have never been good at games like charades or improvisational acting.
14. I have trouble changing my behavior to suit different people and different situations.
15. At a party I let others keep the jokes and stories going.
16. I feel a bit awkward in public and do not show up quite as well as I should.
17. I can look anyone in the eye and tell a lie with a straight face (if for a right end). (Reversed)
18. I may deceive people by being friendly when I really dislike them. (Reversed)

Task Complexity (Haerem & Rau, 2007)

Introduction: Based on your perception of project task characteristics, please indicate the extent to which each of these items applies to the given tasks. (1-very little extent, 5-very great extent)

1. To what extent do the requirements reflect structured tasks? (Reversed)
2. To what extent do you feel that the requirements can be solved by use of a certain method? (Reversed)
3. To what extent do you feel that there are fundamental similarities between the responses to these requirements? (Reversed)
4. To what extent do you feel that you have a mental picture to guide you in responding to the above requirements? (Reversed)
5. To what extent did you come across problems about which you were unsure while responding to these requirements? (Reversed)
6. To what extent did you come up against unexpected factors in responding to the above requirements?
7. To what extent do you feel that your solutions were vague and difficult to anticipate?

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8. To what extent do you feel that it is difficult to identify a solution to the requirements?

Transactive Memory System (Lewis, 2003)

Introduction: Each of the statements below is something that a person might say about his or her work doing the project. Please indicate your own personal feelings about that work by marking how much you agree with each of the statements. (1-strongly disagree, 5-strongly agree)

1. Each team member has specialized knowledge of some aspect of our project.
2. I have knowledge about an aspect of the project that no other team member has.
3. Different team members are responsible for expertise in different areas.
4. The specialized knowledge of several different team members was needed to complete the project deliverables.
5. I know which team members have expertise in specific areas.
6. I was comfortable accepting procedural suggestions from other team members.
7. I trusted that other members' knowledge about the project was credible.
8. I was confident relying on the information that other team members brought to the discussion.
9. When other members gave information, I wanted to double-check it for myself.
10. I did not have much faith in other members' "expertise".
11. Our team worked together in a well-coordinated fashion.
12. Our team had very few misunderstandings about what to do.
13. Our team needed to backtrack and start over a lot.
14. We accomplished the task smoothly and efficiently.
15. There was much confusion about how we would accomplish the task.