ETH zürich

ETH Library

A Strategic Core Role Perspective on Team Coordination: Benefits of Centralized Leadership for Managing Task Complexity in the Operating Room

Journal Article

Author(s):
Pasarakonda, Surabhi; Grote, Gudela; Schmutz, Jan; Bogdanovic, Jasmina; Guggenheim, Merlin; Manser, Tanja

Publication date:
2021-08

Permanent link:
https://doi.org/10.3929/ethz-b-000402761

Rights / license:
In Copyright - Non-Commercial Use Permitted

Originally published in:
Human Factors 63(5), https://doi.org/10.1177/0018720820906041

This page was generated automatically upon download from the ETH Zurich Research Collection.
For more information, please consult the Terms of use.

Human Factors: The Journal of the Human Factors and Ergonomics Society OnlineFirst, published on March 2, 2020 as doi:10.1177/0018720820906041. Copyright © 2020 Human Factors and Ergonomics Society.

A Strategic Core Role Perspective on Team Coordination: Benefits of Centralized Leadership for Managing Task Complexity in the Operating Room

Surabhi Pasarakonda[a], Gudela Grote[a], Jan B. Schmutz[a], Jasmina Bogdanovic[b], Merlin Guggenheim[c], Tanja Manser[d]

[a] Department of Management, Technology, and Economics, ETH Zurich, Zurich, Switzerland

[b] Institute of Nursing Science, University of Basel, Basel, Switzerland

[c] Swissparc, Zurich, Switzerland

[d] School of Applied Psychology, University of Applied Science and Arts Northwestern Switzerland, Olten, Switzerland

Acknowledgements: We thankfully acknowledge the support and participation of the University Hospital Zurich and express our gratitude to the department of Plastic Surgery and Hand Surgery and Prof. Dr. med. Pietro Giovanoli for allowing us to conduct our study within his department. This research was supported, in part, by the Swiss National Science Foundation (grant number, PP00P1_128616).

Address correspondence to Surabhi Pasarakonda, ETH Zurich, Department of Management, Technology, and Economics, Weinbergstrasse 56/58, 8092 Zurich, Switzerland; email address: spasarakonda@ethz.ch

Pasarakonda, S., Grote, G., Schmutz, J. B., Bogdanovic, J., Guggenheim, M., & Manser, T. (2020). A Strategic Core Role Perspective on Team Coordination: Benefits of Centralized Leadership for Managing Task Complexity in the Operating Room. *HUMAN FACTORS* (OnlineFirst), Vol. XX, No. X, Month XXXX, pp. xxx–xxx. DOI:10.1177/0018720820906041. Copyright © 2020 Human Factors and Ergonomics Society.

A Strategic Core Role Perspective on Team Coordination: Benefits of Centralized Leadership for Managing Task Complexity in the Operating Room

Abstract

Objective. We examine whether surgical teams can handle changes in task requirements better when their formal leader and strategic core role holder —i.e. the main surgeon—is central to team coordination.

Background. Evidence regarding the benefits of shared leadership for managing complex tasks is divided. We tested whether a strategic core role holder's centrality in team coordination helps teams to handle different types of task complexity.

Method. We observed coordination as specific leadership behavior in 30 surgical teams during real-life operations. To assess the strategic core role holder's coordination centrality, we conducted social network analyses. Task complexity (i.e., surgical difficulty and unexpected events) and surgical goal attainment were rated in a questionnaire.

Results. In the critical operation phase, surgical difficulty impaired goal attainment when the strategic core role holder's coordination centrality was low, while this effect was non-significant when his/her coordination centrality was high. Unexpected events had a negative effect on surgical goal attainment. However, coordination centrality of the strategic core role holder could not help manage unexpected events.

Conclusion. The results indicate that shared leadership is not beneficial when teams face surgical difficulty during the critical operation phase. In this situation, team coordination should rather be centralized around the strategic core role holder. Contrarily, when unexpected events occur, centralizing team coordination around a single leader does not seem to be beneficial for goal attainment.

Application. Leaders and team members should be aware of the importance of distributing leadership differently when it comes to managing different types of task complexity.

Keywords: strategic core role holder, team coordination, surgical teamwork, task complexity, social network analysis

Précis

An empirical study with 30 real-life surgical teams. We investigated the effect of having a strategic core role holder, central to the teams' coordination network, when task complexities arise. We found that centralized coordination is beneficial when facing surgical difficulty during critical task phases, but not for managing unexpected events.

Introduction

Shared leadership—that is, "an emergent and dynamic team phenomenon whereby leadership roles and influences are distributed among team members" (D'Innocenzo, Mathieu, & Kukenberger, 2016, p. 1968)—is generally considered beneficial for team effectiveness, especially in demanding contexts, such as high risk settings (Klein, Ziegert, Knight, & Xiao, 2006; Künzle, Kolbe, & Grote, 2010; Nicolaides et al., 2014; Pearce & Sims, 2002). However, meta-analyses provide conflicting results regarding the benefits of shared leadership in high task complexity situations (D'Innocenzo et al., 2016; Wang, Waldman, & Zhang, 2014). The conflicting results might be due to differences in the types of teams studied and the different kinds of task complexity these teams faced (Grote, Kolbe, & Waller, 2018; Henrickson Parker, Schmutz, & Manser, 2018).

We address the conflicting results regarding the benefits of shared leadership by studying surgical procedures in which arising task complexities can impair performance. Correspondingly, we focus on two factors of Wood's (1986) definition of task complexity: coordinative complexity and dynamic complexity. Coordinative complexity sees tasks with many interrelated steps as more complex and suggests that they require a higher amount of physical actions and an increase of knowledge and skills in terms of information cues; dynamic complexity is defined as "changes in either the set of required acts and information cues or the relationships between inputs and products can create shifts in the knowledge or skills required for a task" (Wood, 1986, p. 71). To better understand how leadership is distributed in teams in view of different task requirements, we relied on the concept of strategic core roles in teams (Delery & Shaw, 2001; Humphrey, Morgeson, & Mannor, 2009). This concept suggests that some roles have a greater

impact on team effectiveness than others because of exposure to problems and that there may be shifts between roles with changing task demands.

Leadership entails many activities like team development, coordination and managing resources (Zaccaro, Rittman, & Marks, 2001). We focus on coordination, that is defined as sharing information and resources and synchronizing interdependent actions and tasks (Brannick, Roach, & Salas, 1993; Driskell, Salas, & Driskell, 2018; Marks, Mathieu, & Zaccaro, 2001) through implicit and explicit coordination strategies such as task distribution, planning or information sharing (Rico, Sanchez-Manzanares, Gil, & Gibson, 2008; Shah & Breazeal, 2010). Coordination is a frequently enacted function of leadership and is an observable indicator of how leadership is distributed and who holds the strategic core role within teams (Marta, Leritz, & Mumford, 2005; Tschan et al., 2006).

The contribution of our study is threefold. First, we add clarity to the impact of hierarchical versus shared leadership when teams perform different kinds of complex tasks. We analyze leadership in surgical teams which are fairly small groups that work on a well-defined task. In these teams, a central actor within the coordination network might prove beneficial when complexities arise. We strive to better understand the benefits of centralized team coordination as a specific form of leadership in surgical teams as the teams have to manage different kinds of task complexities. Second, we examine leadership through strategic core roles and use observational data and network analysis to identify strategic core role holders in surgical teams. Capturing the team's leadership behavior by collecting observational data allows us to measure the distribution of leadership in a new and differentiated way. So far, research has measured leadership networks through questionnaires (e.g., Small & Rentsch, 2010). However, using observational data on team coordination enables us to directly capture the actual leadership

behaviors. Third, we investigate real-life surgical teams which consist of interprofessional team members working on highly interdependent tasks in a high-risk environment. This allows us to investigate our research question in a unique, natural setting, strengthening the external validity of our results. Thereby, we aim to generate practically relevant insights that are generalizable to teams operating in similar contexts.

The Influence of Task Complexity on Goal Attainment in High-Risk Environments

Task complexity is an important determinant of performance in dynamic settings because it leads to changes in task and situational demands and involves uncertainties and shifts in cues that can impact performance when not managed well (Baard, Rench, & Kozlowski, 2014; Grote, Kolbe, Zala-Mezö, Bienefeld-Seall, & Künzle, 2010). Hence, task complexity is closely linked to the team's goal attainment (Maynard, Kennedy, & Sommer, 2015) and it can impair performance (Espinosa, Kraut, Slaughter, & Lerch, 2002; Weingart, 1992; Xiao et al., 1996).

Surgical teams are frequently exposed to task complexity, involving both complexity of routine tasks regarding their difficulty and occurrences of unexpected events. Managing this complexity can be challenging and have negative effects on performance, unless the team responds appropriately, for example by adapting the way they work together (Fernandez, Kozlowski, Shapiro, & Salas, 2008; Gorman, Amazeen, & Cooke, 2010; Manser, Howard, & Gaba, 2008).

We focused on two factors of task complexity that have been identified as challenging situational demands for surgical teams (Bogdanovic, Perry, Guggenheim, & Manser, 2015): surgical difficulty of planned procedures and the occurrence of unexpected events. The former corresponds to Wood's (1986) definition of coordinative complexity and the latter to dynamic complexity. Surgical difficulty is well assessable by the team prior to surgery (Lacour-Gayet et

al., 2004) due to their knowledge of the patient's clinical diagnosis. Surgical difficulties may affect the process of solving known tasks during surgery (e.g., patient's anatomical structure may lead to difficulties while localizing a lymph node). Additionally, unexpected events may occur due to incidental findings during surgery (e.g., additional tumors to be removed, malfunctioning equipment). Unexpected events happen suddenly and require major adaptations in procedures for which team members might be unprepared because they are not routine events.

In Hypothesis 1, we expect a negative effect of surgical difficulty on surgical teams' goal attainment. More difficult tasks require teams to use more complex interactions and sequencing of skills and knowledge (Wood, 1986). Few studies have examined effects of surgical difficulty on goal attainment in medical settings (e.g., Xiao et al., 1996; Xiao & Mackenzie, 1998), while others examined effects of task difficulty on team performance (e.g., Luciano, Bartels, D'Innocenzo, Maynard, & Mathieu, 2018; Vashdi, Bamberger, & Erez, 2013).

Hypothesis 1: *A higher level of surgical difficulty is associated with lower team goal attainment.*

Unexpected events have been studied more frequently, providing evidence that distractions, interruptions and complications during surgery harm team performance (Goodell, Cao, & Schwaitzberg, 2006; Healey, Primus, & Koutantji, 2007; Healey, Sevdalis, & Vincent, 2006a; Kurmann et al., 2012). In Hypothesis 2, we aimed to replicate this finding and thus, hypothesize the following:

Hypothesis 2: *The occurrence of unexpected events is associated with lower team goal attainment.*

Shared Leadership and Coordination Behavior of the Strategic Core Role Holder

Teams have an advantage in that specific tasks, which are paired with particular roles, can be distributed across team members and responsibilities can be shared within the team (Bell & Kozlowski, 2002). We adopted the role composition perspective proposed by Humphrey et al. (2009) that conceptualizes roles as a set of individual behaviors resulting from interactions with other team members and the expectations regarding others' behavior expressed in these interactions (Stewart, Fulmer, & Barrick, 2005). Roles are often predefined and linked to responsibilities based on skills and knowledge of team members. They are essential to teams and can be occupied by multiple individuals (Hackman, 1987; Sundstrom, De Meuse, & Futrell, 1990; Woods & West, 2010). A clear role allocation and synchronization among team members is necessary to ensure good coordination and performance (Bell & Kozlowski, 2002; Mumford, Van Iddekinge, Morgeson, & Campion, 2008; Steiner, 1972). Which roles are most critical for team performance can change when task demands and situational conditions change. The strategic core is defined as the role(s) in "a team that (a) encounter more of the problems that need to be overcome in the team, (b) have a greater exposure to the tasks that the team is performing, and (c) are more central to the workflow of the team" (Humphrey et al., 2009, p. 50).

Extant research has usually defined the strategic core role holder a priori, by considering the task characteristics and the responsibilities they hold within these tasks (Humphrey et al., 2009). The strategic core role holder's influence on their teams is beneficial for team performance (Delery & Shaw, 2001). However, to date, the influence of strategic core role holders has mostly been studied in self-managed teams where no formal leader exists (Pearsall & Ellis, 2016). Our study context is thus of special interest because the formal leadership role in surgical teams is clearly defined, and behavioral deviations from this role may be detrimental for

team effectiveness. We examine whether the a priori defined strategic core role holders are central in the team's actual coordination network, because a mismatch between role assignments and actual behavior will likely be related to lower team effectiveness.

Strategic Core Role Holders in Surgical Teams

Surgical teams have an interprofessional composition (Table 1), comprising various roles that perform different, but highly interdependent tasks whilst mutually supporting each other to achieve the same goal (Catchpole, Mishra, Handa, & McCulloch, 2008). Healey, Undre, and Vincent (2006b) developed a model of intraoperative teamwork that considers surgeon and scrub-nurse as the main roles because they need to share an understanding of each other's actions and skills. The importance of these two roles is evident in the general structure of all operations, consisting of three distinct phases (Table 2). Even though the formal leadership role is held by the main surgeon, it is worth looking at coordination behaviors between all role holders within surgical teams to determine who takes the position of the strategic core role holder. We expect that in surgical teams the team member holding the strategic core role may be either the main surgeon or scrub-nurse, depending on the task phase.

Table 1.

Task Distribution within the Surgical Team

Role	Task distribution
Surgeon	Makes the incision, holds main responsibility for the operation and delegates tasks to other team members
Anesthetist	Provides anesthesia, monitors patient's well-being and keeps the surgeon informed
Scrub-nurse	Provides surgical instruments and is the main reference person for the operating surgeon
Circulating nurse	Responsible for actions that must be done from the periphery of the operating room (e.g. fetching supplies, preparing equipment)

Table 2.

Phases, Potential Complexities and Roles Involved during Operations

Task phases (Katz, 1981)	Description	Task complexities that can arise due to:	Strategic core role holders involved
Phase 1: Incision	Less complex; fairly routine tasks	Wrong marking or unexpected patient reactions that have a direct impact on forthcoming Phases 2 and 3.	Main surgeon comes in and takes over the patient from the scrub-nurse at some point.
Phase 2: Excision & Repair	Most complex phase; unexpected events can occur	The possibility of damaging relevant anatomic structures or deterioration of patient well-being.	Main surgeon and scrub-nurse need to be able to rely on each other's decisions, requests and actions.
Phase 3: Wound Closure	Most routine phase within operations	The dependencies of the two preceding phases or due to the patient's well-being.	Main surgeon and scrub-nurse.

The operation phases highlight potential task complexities, dependencies between various strategic core role holders and their need for coordination. Having a strategic core role holder who is central to the team's coordination presumably helps them manage these complexities. Depending on the phase, the strategic core role holder can change due to different tasks and responsibilities held within the team. Coordination centrality is an indicator for a person's control of communication within a team (Freeman, 1977). We therefore first examine who the strategic core role holders are in the various task phases and then investigate whether the strategic core role holder's coordination centrality is beneficial for managing different types of task complexity.

Hypothesis 3: *The strategic core role holder's coordination centrality moderates the negative relationship between surgical difficulty and goal attainment, such that the relationship is weakened with higher coordination centrality of the strategic core role holder.*

Hypothesis 4: *The strategic core role holder's coordination centrality moderates the negative relationship between the occurrence of unexpected events and goal attainment,*

such that the relationship is weakened with higher coordination centrality of the strategic core role holder.

Methods

This research complied with the American Psychological Association Code of Ethics. A waiver for a formal ethics evaluation was granted (Req-2011-0313) from the ethics committee of the canton of Zurich. After being informed about study content, procedure and usage of data collection, all participants provided written consent.

Sample and Procedure

We collected multimethod, multisource data of surgical teams. We observed 30 sentinel lymph node biopsies at the Division of Plastic Reconstructive Surgery of a Swiss University Hospital. During surgery, team coordination behavior was coded by two trained observers on iPads using the application INTERACT Obansys (Mangold International GmbH, Arnstorf). Due to limited space around the patient, noisiness in the operating room and as agreed upon with the hospital, only one observer at a time was present during live-coding. Therefore, interrater agreement could not be assessed for real-life observations. However, we conducted multiple days of rater training coding video recordings of surgical procedures in real time. We achieved substantial agreement with Cohens Kappa scores of at least .70 (Landis & Koch, 1977). During training, videos were never paused or replayed, therefore, challenges of live-coding (e.g., the pace of the interactions) were simulated.

The average team size was 5.12 (SD = .74) but varied over all three phases. Team size in Phase 1 ranged from 2 to 7 (M = 4.77, SD = 1.19), in Phase 2 from 3 to 7 (M = 4.87, SD = 1.41) and Phase 3 from 4 to 8 (M = 5.73; SD = 1.02). Not all team members were present in the operating room in all the phases. We distinguished the following roles within the surgical teams:

main surgeon, second surgeon, up to two assisting surgeons, scrub-nurse, circulating nurse, up to two anesthetists and, occasionally, a clinician not involved in the procedure.

Measures

Surgical difficulty, unexpected events and goal achievement were measured using a questionnaire. Due to time constraints and the possibility of interrupting the workflow within the surgical department we had to negotiate with the participating department on using binary response options while assessing surgical difficulty and unexpected events. Coordination centrality of the strategic core role holder was measured via observation.

Surgical Difficulty. We measured the degree of surgical difficulty postoperatively with one question: "In relation to typical surgical procedures of this type (sentinel-lymph node biopsies), how difficult would you assess the surgical procedure that was just carried out?" (0 = low surgical difficulty, 1 = high surgical difficulty). The designated surgeon answered with the aid of two technical anchors (i.e., "No positional relationship of the sentinel lymph node to essential anatomical structures; enough distance from the primary tumor, so that the gamma probe works well. Post-excision primary tumor can be closed or covered without any problems." for low surgical difficulty and "Closer positional relationships to essential anatomical structures; insufficient distance from the primary tumor, so that the gamma probe does not function well. Post-excision primary tumor required a more elaborate covering/wound closure" for high surgical difficulty).

Unexpected Events. After the operation, the main surgeon indicated whether unexpected events had occurred during the surgical procedure (0 = no, 1 = yes).

Coordination. Coordination was assessed on the team level using CoMeT-S (Coordination in Medical Teams–Surgery). CoMeT-S was based on a coding system for coordination in

anesthesia (Manser et al., 2008) that has been used to investigate healthcare teams (Burtscher, Wacker, Grote, & Manser, 2010; Schmutz, Hoffmann, Heimberg, & Manser, 2015). To adapt the coding system for surgery we compared it with observational studies on surgical teamwork (Hull, Arora, Kassab, Kneebone, & Sevdalis, 2011; Parker, Flin, McKinley, & Yule, 2013; Yule, Flin, Brown, Maran, & Rowley, 2006), used insights from an interview study on adaptive coordination in surgery (Bogdanovic et al., 2015), and unstructured field observations. Three human factors experts trained in team observation piloted and refined the coding system using the constant comparative method.

CoMeT-S consists of 13 mutually exclusive codes which are grouped into four main categories: Information management (IM), task management (TaM), team management (TeM) and non-pertinent communication (NPC). We focused on the two main categories IM and TaM (Figure 1) since the occurrence of TeM in relation to the overall coordination was lower than 3%. NPC was excluded from our analyses since we were only interested in procedure related communication.

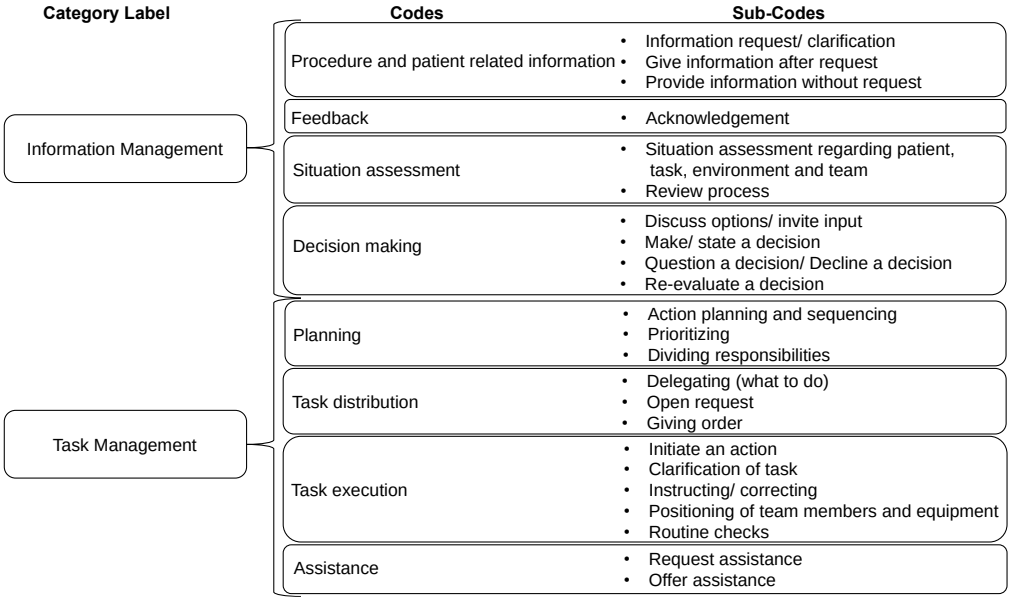

Figure 1. Coding system for coordination in medical teams in surgery (CoMeT-S).

Strategic Core Role Holder Coordination Centrality. We conceptualized the strategic core role holder through his/her centrality in coordination patterns exhibited in a team (Summers, Humphrey, & Ferris, 2012). Strategic core role holder coordination centrality was calculated using the coded coordination behavior and determined by Actor-Sequences resulting from a lag-sequential analysis (Bakeman & Gottman, 1997). The lag-sequential analysis was conducted with INTERACT Obansys (Mangold International GmbH, Arnstorf) using sequences (lags) of five seconds. Actor-Sequences result from the sequence of two actors' coordination behaviors. An example is depicted in Figure 2: Surgeon 1 (first actor) shows a coordination behavior, thereafter the scrub-nurse (second actor) shows another coordination behavior. This leads to the Actor-Sequence "scrub-nurse shows coordination behavior after surgeon 1". In other words, the first actor elicits a coordination behavior of the second actor.

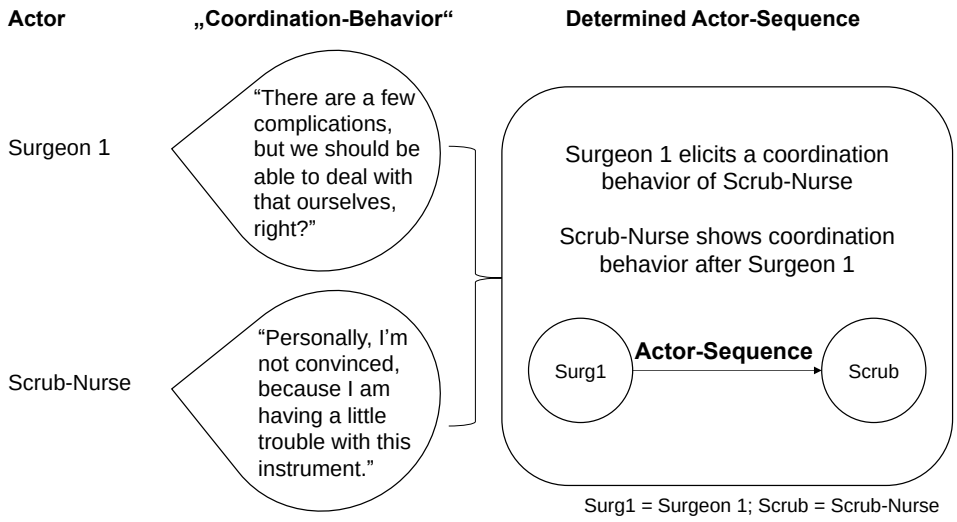

Figure 2. Determining the Actor-Sequence through lag-sequential analysis.

Determining the Actor-Sequence allowed us to establish the chronological sequence of two individual team members' coordination behaviors. Using social network analysis (Scott & Carrington, 2011), we then analyzed the previously defined Actor-Sequences and their

relationship. One Actor-Sequence was equal to one tie within the network that we observed. Thus, multiple Actor-Sequences between the same two actors led to a stronger tie between the two actors (Figure 3). We drew from social network analysis by using the specific measure *betweenness centrality*. Betweenness centrality indicates a person's control of communication within a team (Brandes, Borgatti, & Freeman, 2016; Freeman, 1977) and measures the extent that a node sits *between* pairs of other nodes in the network. A node with high *betweenness* is prominent, because that node is in a position to observe/control the flow of information in the network (Luke, 2015). Within this study, the actor is considered to have a high betweenness centrality and thus be central to the team's coordination behavior network when he/she elicits multiple coordination behaviors of other team members and thus creates strong ties between him-/herself and the other actors due to the accumulation of multiple Actor-Sequences (Figure 3).

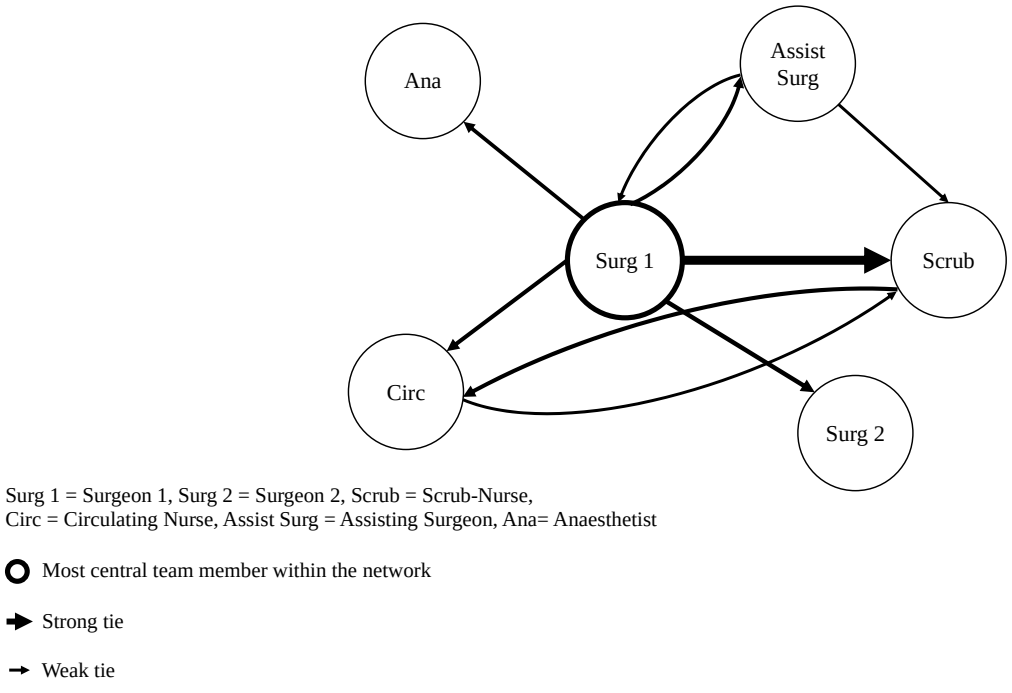

Figure 3. Example of a team's coordination behavior network.

Goal Attainment. After the operation, goal attainment was assessed with five items (Table 3) by the designated surgeon. Teams could attain a score between 0 and 5. The designated surgeon can be considered most experienced regarding the surgical procedure and was therefore considered to be able to assess surgical goal attainment very precisely.

Table 3

Goal Attainment Items and Score

Items	Score
Localization of the sentinel lymph node was successful	0 = no/ 1 = yes
Removal sentinel lymph node intact	0 = no/ 1 = yes
Lesion of relevant anatomic structures	1 = no/ 0 = yes
Excision and wound closure/ definite covering of primary tumor carried out	0 = no/ 1 = yes
Surgery without essential bleeding	0 = no/ 1 = yes
Goal Attainment Score	**0 – 5 Points**

Data Analyses

We controlled for surgery duration (Hypotheses 1 and 2) and surgical phase (Hypotheses 3 and 4) to account for the fact that during longer surgeries the chances for complexities to occur and the amount of coordination activities increases. Since complexities occurring in Phases 1 or 2 could also affect further phases, we tested Hypotheses 3 and 4 separately for all phases. To test our hypotheses, we conducted multiple hierarchical regression analyses.

Descriptive Analyses

To verify whether the main surgeon or the scrub-nurse were indeed the strategic core role holders in the observed surgeries, we analyzed their centrality for all three phases as an indicator of them being core to the task. Figure 4 shows how frequently the main surgeon and scrub-nurse

took the core role holder position during a given phase. Despite the strategic core role not being as clearly allocated to the main surgeon in Phase 3, the main surgeon can be seen overall as strategic core role holder. Therefore, in the following, we focus on the coordination behavior of the main surgeon during all three phases.

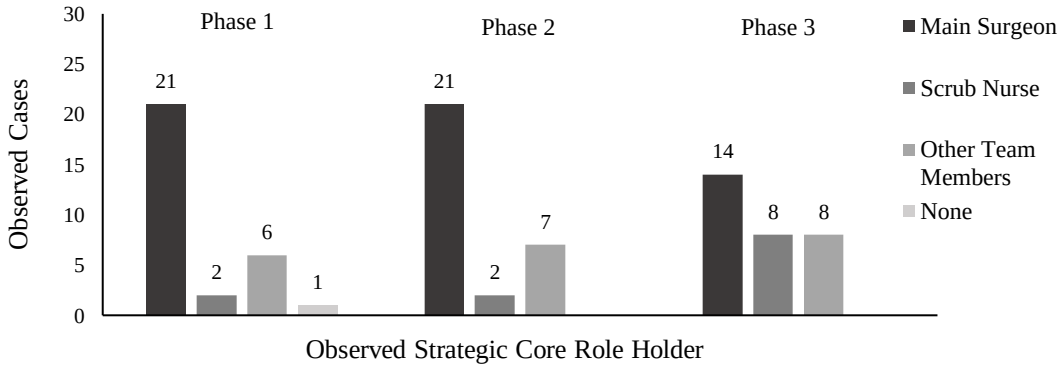

Figure 4. Descriptive results of observed strategic core role holder. "Other team members" refer to roles such as second surgeon, assisting surgeon, circulating nurse or anesthetist.

Results

Table 4 displays the descriptive statistics of all study variables.

Table 4
Descriptive Statistics and Correlations between Study Variables

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
Outcome variable											
1. Goal Attainment	4.67[a]	0.66[a]	–								
Control variables											
2. Duration Total (in sec.)	2318.44	1070.34	-.49**	–							
3. Duration P1 (in sec.)	508.18	311.71	-.07	.40*	–						
4. Duration P2 (in sec.)	835.40	733.58	-.55**	.81**	.05	–					
5. Duration P3 (in sec.)	974.87	520.69	-.20	.68**	.14	.22	–				
Predictor variables											
6. Surgical Difficulty[b]	0.30	–	-.56**	.70**	.35	.56**	.38*	–			
7. Unexpected Events[c]	0.23	–	-.57**	.53**	.13	.60**	.16	.67**	–		
8. SCRH Coordination Centrality P1	5.63	3.71	-.02	.17	.37*	.05	.06	.08	-.07	–	
9. SCRH Coordination Centrality P2	5.77	4.77	.05	.28	.09	.42*	-.07	.22	.17	.18	–
10. SCRH Coordination Centrality P3	5.39	5.89	.24	.06	.38*	-.20	.17	.05	-.18	.08	-.12

Note. $N = 30$. [a]The mean plus standard deviation is higher than the maximum value because the mean value is close to the maximum of the scale (Max = 5), [b]0 = Low surgical difficulty, 1 = High surgical difficulty. [c]0 = No unexpected event occurred, 1= Unexpected event occurred. P1 = Phase 1, P2 = Phase 2, P3= Phase 3. SCRH = Strategic Core Role Holder.
*$p < .05$; **$p < .01$

Table 5 shows the estimates for the relationship of surgical difficulty and goal attainment. We did not find a significant effect of surgical difficulty on goal attainment (b = -.60, SE = 0.31, p = .066). Thus, Hypothesis 1 received no support.

The results for Hypothesis 2 are displayed in Table 6, which indicate that the occurrence of unexpected events relates to lower surgical goal attainment (b = -0.65, SE = 0.28, p = .026) corroborating Hypothesis 2. We calculated the effect size Cohen's f^2 for hierarchical multiple regression and found $f^2 = 0.21$, which indicates a medium effect (Cohen, 1988).

Table 5

Hierarchical Regression Analysis Predicting the Effect of Surgical Difficulty on Surgical Goal Attainment

	b	*SE*	*t*	*p*	R^2	*F*	ΔR^2	ΔF
Step 1					.24	9.00**		
Duration Total	.00	0.00	-3.00	.006				
Step 2					.33	6.77**	.09	3.68**
Surgical Difficulty[a]	-.60	0.31	-1.92	.066				

Note. N = 30 Teams. [a] 0 = Low surgical difficulty, 1 = High surgical difficulty
**p < .01

Table 6

Hierarchical Regression Analysis Predicting the Effect of Unexpected Events on Surgical Goal Attainment

	b	*SE*	*t*	*p*	R^2	*F*	ΔR^2	ΔF
Step 1					.24	9.00**		
Duration Total	.00	0.00	-3.00	.006				
Step 2					.37	8.01**	.13	8.01**
Unexpected Events[b]	-.65	0.28	-2.36	.026				

Note. N = 30 Teams. [b] 0 = No unexpected events occurred, 1 = Unexpected events occurred.
**p < .01

In accordance with Hayes (2018) we can expect that surgical difficulty's effect on goal attainment will be moderated by coordination centrality of the strategic core role holder even

though the effect of surgical difficulty on goal attainment was not significant. Table 7 depicts our estimates for Hypothesis 3, investigating whether the negative relationship between surgical difficulty and goal attainment is lower when the core team member is high on coordination centrality than when he/she is low on coordination centrality, in all three phases of the surgery. We found no significant interaction effect in Phase 1 (b = .08, SE = 0.07, p = .221) or Phase 3 (b = .04, SE = 0.04, p = .226). In Phase 2, our analysis revealed a significant interaction effect between surgical difficulty and the core team member's coordination centrality (b = .09, SE = 0.04, p = .036). Simple slope analysis (Aiken & West, 1991) revealed a significant negative effect of surgical difficulty on goal attainment for teams with low strategic core role holder coordination centrality in Phase 2 (b = -1.21, p < .001) but not for high strategic core role holder coordination centrality in Phase 2 (b = -.53, p = .08; see Figure 5). Additionally, we computed the effect size for the significant interaction effect between surgical difficulty and strategic core role holder coordination centrality in Phase 2, which disclosed a large effect (Cohen's f^2 = 0.58). Therefore, Hypothesis 3 was partially supported.

Table 8 displays the results for Hypothesis 4, in which we investigate whether the strategic core role holder's coordination centrality moderates the relationship between the occurrence of unexpected events and goal attainment. We found no significant interaction effects for Phase 1 (b = .09, SE = 0.08, p = .269), Phase 2 (b = .05, SE = 0.04, p = .284) or Phase 3 (b = .05, SE = 0.07, p = .493). Thus, we rejected Hypothesis 4.

Table 7

Effects of Strategic Core Role Holder Coordination Centrality on the Relation between Surgical Difficulty and Goal Attainment

	Phase 1								Phase 2								Phase 3							
	b	*SE*	*t*	*p*	R^2	*F*	$\triangle R^2$	$\triangle F$	*b*	*SE*	*t*	*p*	R^2	*F*	$\triangle R^2$	$\triangle F$	*b*	*SE*	*t*	*p*	R^2	*F*	$\triangle R^2$	$\triangle F$
Step1					.01	.14							.30	12.21**							.04	1.11		
Duration Phase x (in sec.)	.00	0.00	-.37	.711					.00	0.00	-3.50	.002					.00	0.00	-1.05	.301				
Step 2					.33	4.33*	.33	6.39**					.48	57.84**	.17	4.24*					.39	5.47**	.35	7.39**
Surgical difficulty[a]	-.87	0.24	-3.58	.001					-.48	0.25	-1.93	.065					-.80	0.24	-3.39	.002				
SCRH CC Phase x	-.01	0.03	-.18	.859					.05	0.02	2.09	.047					.03	0.02	1.76	.090				
Step 3					.37	3.71*	.04	1.58					.56	7.99***	.09	4.91*					.42	4.47**	.03	1.29
Surgical difficulty[a] * SCRH CC Phase x	.08	0.07	1.26	.221					.09	0.04	2.22	.036					.04	0.04	1.14	.266				

Note. $N = 30$. [a]0 = Low surgical difficulty, 1 = High surgical difficulty. Phase x = Given Phase of analysis. SCRH CC = Strategic Core Role Holder Coordination Centrality
*$p < .05$; **$p < .01$; ***$p < .001$

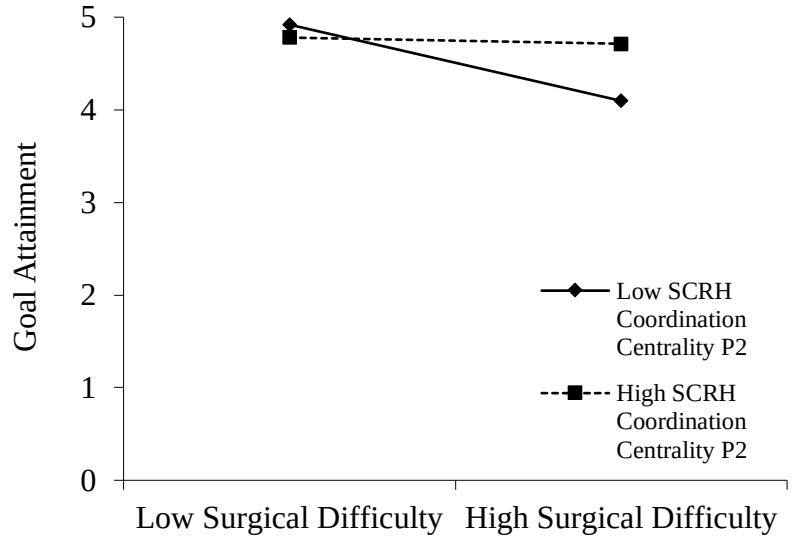

Figure 5. Plot of surgical difficulty × strategic core role holder (SCRH) coordination centrality in Phase 2 predicting goal attainment.

Table 8

Effects of Strategic Core Role Holder Coordination Centrality on the Relation between Unexpected Events and Goal Attainment

	Phase 1								Phase 2								Phase 3							
	b	*SE*	*t*	*p*	R^2	*F*	$\triangle R^2$	$\triangle F$	*b*	*SE*	*t*	*p*	R^2	*F*	$\triangle R^2$	$\triangle F$	*b*	*SE*	*t*	*p*	R^2	*F*	$\triangle R^2$	$\triangle F$
Step1					.01	.14							.30	12.21**							.04	1.11		
Dur Phase x (in sec.)	.00	0.00	-.37	.711					.00	0.00	-3.50	.002					.00	0.00	-1.05	.301				
Step 2					.33	4.18*	.32	6.17**					.47	7.57**	.16	3.95*					.36	4.87**	.32	6.54**
Unexpected Events[b]	-.89	0.25	-3.51	.002					-.50	0.28	-1.80	.084					-.79	0.25	-3.15	.004				
SCRH CC Phase x	-.01	0.03	-.43	.672					.04	0.02	1.93	.064					.02	0.02	1.07	.295				
Step 3					.36	3.49*	.03	1.28					.49	6.02**	.02	1.20					.37	3.70*	.01	.49
Unexpected Events[b] * SCRH CC Phase x	.09	0.08	1.13	.269					.05	0.04	1.10	.284					.05	0.07	.70	.493				

Note. $N = 30$. [b]0 = No unexpected events occurred, 1= Unexpected events occurred. Phase x = Given Phase of analysis. SCRH CC = Strategic Core Role Holder Coordination Centrality.
*$p < .05$; **$p < .01$

Discussion

Results show that during the more critical parts of surgeries, teams in which the strategic core role holder was less central to the team's coordination network experienced more negative effects of surgical difficulty on goal attainment compared to teams in which the strategic core role holder was more central to the team's coordination. However, we did not find a main effect of surgical difficulty on goal attainment. In contrast, regarding the effects of unexpected events on goal attainment, we found the hypothesized negative main effect, but no interaction with the strategic core role holders' coordination centrality. Thus, this study suggests that teams might need to adapt leadership behavior in terms of centralized coordination to the type of task complexity.

Leadership research suggests that identifying the structural position of individuals within teams helps to understand who the team leader is (Balkundi & Kilduff, 2005; Freeman, Roeder, & Mulholland, 1979). Pearce and Conger (2002) have argued that highly centralized networks are indicative of having one actor who is central to fulfilling the leadership role and showing specific leadership behaviors (e.g., coordination). In contrast, decentralized coordination networks can be an indicator of shared leadership (Mayo, Meindl, & Pastor, 2002). Our results support the findings by D'Innocenzo et al. (2016) that shared leadership—in our case indicated by lower coordination centrality of the formal leader—is not beneficial for performance during difficult surgical tasks. Surgical difficulty goes along with an increase of multiple concurrent tasks that require team members to sequence their actions by coordinating their skills and knowledge adequately to ensure goal attainment (Wood 1986; Xiao & Mackenzie, 1998). Xiao & Mackenzie (1998) showed that surgical difficulty leads to lower goal attainment especially when teams are under pressure to seek alternative solutions or when it comes to diffusion of

responsibility within the team. In line with our results, it seems to be beneficial to have a strategic core role holder who is simultaneously the formal leader when surgical difficulties arise. Having one leader provides a clear channel for team coordination and prevents diffusion of responsibility. Moreover, the benefit of shared leadership for handling coordinative complexity and thereby maintaining goal attainment might depend on the type of team. Self-managed teams are set up to share responsibility for task fulfilment without a designated formal leader, which forces them to learn how to handle problems arising from diffusion of responsibility (Solansky, 2008). In contrast, surgical teams have a built-in hierarchy to be able to clearly assign responsibility. Our results show that being able to rely on this built-in hierarchy seems to be especially important during critical surgical phases.

We did not find interaction effects between surgical difficulty and coordination centrality of the strategic core role holder for Phases 1 and 3. One reason could be that these phases are more routine and the task is less difficult. Another possible explanation could be that in Phases 1 and 3, multiple roles (e.g., anesthetists and scrub nurses) and various skills are needed to ensure goal attainment. Past research has assumed that when teams face task complexity, the probability that one single person possesses all required skills and knowledge is small (Bligh, Pearce, & Kohles, 2006; Pearce & Manz, 2005).

The strong negative relationship between unexpected events and goal attainment provides evidence that surgical goal attainment can be substantially impaired when teams face unexpected events. Together with previous research regarding negative effects of distractions and interruptions on surgical team performance (Goodell et al., 2006; Healey et al., 2006a; 2007; Kurmann et al., 2012) this emphasizes the criticality of managing unexpected events.

We further assumed that the strategic core role holder's coordination centrality would mitigate the negative effect of unexpected events on goal attainment. However, we did not find this buffering effect. This may be due to the different nature of task complexity. While tasks can be characterized beforehand to be difficult, unexpected events arise suddenly and interrupt the routine procedure which requires the team to adapt (Burtscher et al., 2011; Grote et al., 2010; Manser et al., 2008). When unexpected events occur and the formal leader is less experienced than other team members, shared leadership might be more important for the team to activate knowledge and skills of several team members (Bligh et al., 2006; Künzle, et al., 2010). Consequently, centralized coordination through one actor is not beneficial in this situation. Summarizing, dynamic complexities (i.e., unexpected events) seem to pose different challenges to the team's coordination behavior than coordinative complexity (i.e., surgical difficulty).

Limitations and Future Research

Studies investigating teams using social network analysis are often based on self-report data. In contrast, we used observational data of surgical teams performing real-life operations. The downside to relying on observation of actual team behavior was the restricted accessibility of the sample leading to the limited sample size of 30 teams. Thus, our study had low statistical power, making it hard to detect small to medium effects.

Surgical teams have limited time to participate in research, so the number of questions and optional answers in our questionnaire were restricted due to negotiation with the participating department. Consequently, surgical difficulty and unexpected events were measured dichotomously, constraining our ability to draw conclusions about the effects of different degrees of surgical difficulty or event severity.

Our analyses were correlational therefore causality cannot be assumed. We cannot completely rule out that the effects are the other way around. For example, when surgical difficulty is high and the main surgeon is central to team coordination, he/she could have rated goal attainment higher than when he/she was less central to the team's coordination. Future studies should consider longitudinal designs while investigating real-life surgical teams.

We used observational data to capture coordination centrality overall by combining all categories from the observation system CoMeT-S. This procedure should constitute a more robust measure of coordination centrality compared to using subcategories of CoMeT-S which occurred with lower frequency. Future studies might focus on lower level categories to capture coordination behavior more fine-grained which might help to develop an even better understanding of different forms of leadership.

Finally, we focused on surgical teamwork and on a routine surgical procedure. Generalizability to non-routine surgical procedures and other contexts outside of the medical field needs to be tested. Based on our findings, it might be interesting to further investigate various factors of task complexity to find out when centralized coordination behaviors or shared leadership approaches are more beneficial. Given that centralized coordination behavior of the formal leader does not seem to be beneficial when dynamic complexities arise, future research should aim to disentangle what kinds of leadership behaviors help to manage dynamic complexities.

Practical Implications

Our results have practical implications for increasing surgical staff awareness of how important their coordination behaviors are for goal attainment, depending on their role within the team. We highlight the relevance of role-based coordination and leadership behavior in

managing task complexities. Surgical team members who are strategically core to the task should be aware that when they face high surgical difficulty, they need to channel coordination to ensure goal attainment. At the same time, the strategic core role holder as well as other team members should be aware that for handling unexpected events, coordination centralized around one actor is not beneficial for goal attainment. These insights can inform training of surgical teams on how to manage different forms of task complexity.

Furthermore, our results have implications for patient safety. By supporting teams to more effectively lead and coordinate team efforts in face of task complexities, they can achieve higher goal attainment and in turn, ensure patient safety also in highly demanding situations.

Conclusion

In line with Humphrey et al.'s (2009) strategic core role theory, we underscore the importance of looking at strategic core role holders within teams. We used observational data and network analysis to identify strategic core role holders and thereby introduced a differentiated measure for the distribution of leadership within teams. We found that having a strategic core role holder, who is simultaneously the formal leader and central to team coordination, helps teams achieve better goal attainment when task-related difficulties arise in critical task phases, though not when unexpected events occur. By taking a strategic core role perspective on coordination we make a first step in showing that leadership should be viewed as a dynamic interaction process that can vary depending on task demands.

Key Points

- The main surgeon was found to be the strategic core role holder within the surgical team.

- Surgical teams that had a strategic core role holder who was central to the team's coordination were found to achieve better goal attainment despite facing surgical difficulties during the critical phases of a task.
- Leaders and team members should be aware of the importance of channeling coordination differently when it comes to managing different types of task complexities.

REFERENCES

Aiken, L. S., & West, S. G. (1991). Multiple regression: Testing and interpreting interactions. Thousand Oaks, CA: Sage.

Baard, S. K., Rench, T. A., & Kozlowski, S. W. J. (2014). Performance Adaptation. *Journal of Management, 40*, 48–99. doi:10.1177/0149206313488210

Bakeman, R., & Gottman, J. M. (1997). Observing interaction: An introduction to sequential analysis (2nd ed.). Cambridge, UK: Cambridge University Press. doi:10.1017/cbo9780511527685

Balkundi, P., & Kilduff, M. (2005). The ties that lead: A social network approach to leadership. *The Leadership Quarterly, 16*, 941–961. doi:10.1016/j.leaqua.2005.09.004

Bell, B. S., & Kozlowski, S. W. J. (2002). A typology of virtual teams. *Group & Organization Management, 27*, 14–49. doi:10.1177/1059601102027001003

Bligh, M. C., Pearce, C. L., & Kohles, J. C. (2006). The importance of self- and shared leadership in team based knowledge work: A meso-level model of leadership dynamics. *Journal of Managerial Psychology, 21*, 296–318. doi:10.1108/02683940610663105

Bogdanovic, J., Perry, J., Guggenheim, M., & Manser, T. (2015). Adaptive coordination in surgical teams: An interview study. *BMC Health Services Research, 15*, 1-12. doi:10.1186/s12913-015-0792-5

Brandes, U., Borgatti, S. P., & Freeman, L. C. (2016). Maintaining the duality of closeness and betweenness centrality. *Social Networks, 44*, 153–159. doi:10.1016/j.socnet.2015.08.003

Brannick, M. T., Roach, R. M., & Salas, E. (1993). Understanding team performance: A multimethod study. *Human Performance, 6*, 287–308. doi:10.1207/s15327043hup0604_1

Burtscher, M. J., Manser, T., Kolbe, M., Grote, G., Grande, B., Spahn, D. R., & Wacker, J. (2011). Adaptation in anaesthesia team coordination in response to a simulated critical event and its relationship to clinical performance. *British Journal of Anaesthesia, 106*, 801–806. doi:10.1093/bja/aer039

Burtscher, M. J., Wacker, J., Grote, G., & Manser, T. (2010). Managing nonroutine events in anesthesia: The role of adaptive coordination. *Human Factors, 52*, 282–294. doi:10.1177/0018720809359178

Catchpole, K., Mishra, A., Handa, A., & McCulloch, P. (2008). Teamwork and error in the operating room: Analysis of skills and roles. *Annals of Surgery, 247*, 699–706. doi:10.1097/SLA.0b013e3181642ec8

Cohen, J. (1988). Statistical power analysis of the behavioral sciences (2nd edition). New York, NY: Lawrence Erlbaum Associates.

Delery, J. E., & Shaw, J. D. (2001). The strategic management of people in work organizations: Review, synthesis, and extension. In GR Ferris (Ed.), *Research in Personnel and Human Resources Management* (pp. 165–197). Bingley, Emerald Group Publishing Limited. doi:10.1016/S0742-7301(01)20003-6

D'Innocenzo, L., Mathieu, J. E., & Kukenberger, M. R. (2016). A meta-analysis of different forms of shared leadership–team performance relations. *Journal of Management, 42*, 1964–1991. doi:10.1177/0149206314525205

Driskell, J. E., Salas, E., & Driskell, T. (2018). Foundations of teamwork and collaboration. *American Psychologist, 73*, 334–348. doi: 10.1037/amp0000241

Espinosa, A., Kraut, R., Slaughter, S., & Lerch, J. (2002). Shared mental models, familiarity, and coordination: A multi-method study of distributed software teams. *ICIS 2002 Proceedings, 39.* Retrieved from http://aisel.aisnet.org/icis2002/39

Fernandez, R., Kozlowski, S. W. J., Shapiro, M. J., & Salas, E. (2008). Toward a definition of teamwork in emergency medicine. *Academic Emergency Medicine, 15*, 1104–1112. doi:10.1111/j.1553-2712.2008.00250.x

Freeman, L. C. (1977). A set of measures of centrality based on betweenness. *Sociometry, 40*, 35–41. doi:10.2307/3033543

Freeman, L. C., Roeder, D., & Mulholland, R. R. (1979). Centrality in social networks: II. Experimental results. *Social Networks, 2*, 119–141. doi:10.1016/0378-8733(79)90002-9

Goodell, K. H., Cao, C. G. L., & Schwaitzberg, S. D. (2006). Effects of cognitive distraction on performance of laparoscopic surgical tasks. *Journal of Laparoendoscopic & Advanced Surgical Techniques, 16*, 94–98. doi:10.1089/lap.2006.16.94

Gorman, J. C., Amazeen, P. G., & Cooke, N. J. (2010). Team coordination dynamics. *Nonlinear Dynamics, Psychology, and Life Sciences, 14*, 265–289. Retrieved from https://www.researchgate.net/profile/Jamie_Gorman/publication/44851300_Team_Coordination_Dynamics/links/0046351e82bbba4060000000/Team-Coordination-Dynamics.pdf

Grote, G., Kolbe, M., & Waller, M. J. (2018). The dual nature of adaptive coordination in teams. *Organizational Psychology Review*, *8*, 125–148. doi:10.1177/2041386618790112

Grote, G., Kolbe, M., Zala-Mezö, E., Bienefeld-Seall, N., & Künzle, B. (2010). Adaptive coordination and heedfulness make better cockpit crews. *Ergonomics*, *53*, 211–228. doi:10.1080/00140130903248819

Hackman, J. R. (1987). The design of work teams. In *Handbook of Organizational Behavior*. (J. W. Lorsch, Ed.) (pp. 315–342). Englewood Cliffs, NJ: Prentice Hall.

Hayes, A. F. (2018). Introduction to mediation, moderation, and conditional process analysis (2nd edition). New York, NY:Guilford Publications.

Healey, A. N., Primus, C. P., & Koutantji, M. (2007). Quantifying distraction and interruption in urological surgery. *Quality & Safety in Health Care*, *16*, 135–139. doi:10.1136/qshc.2006.019711

Healey, A. N., Sevdalis, N., & Vincent, C. A. (2006a). Measuring intra-operative interference from distraction and interruption observed in the operating theatre. *Ergonomics*, *49*, 589–604. doi:10.1080/00140130600568899

Healey, A. N., Undre, S., & Vincent, C. A. (2006b). Defining the technical skills of teamwork in surgery. *Quality & Safety in Health Care*, *15*, 231–234. doi:10.1136/qshc.2005.017517

Henrickson Parker, S., Schmutz, J. B., & Manser, T. (2018). Training needs for adaptive coordination: Utilizing task analysis to identify coordination requirements in three different clinical settings. *Group & Organization Management*, *43*, 504–527. doi:10.1177/1059601118768022

Hull, L., Arora, S., Kassab, E., Kneebone, R., & Sevdalis, N. (2011). Observational teamwork assessment for surgery: Content validation and tool refinement. *Journal of the American College of Surgeons*, *212*, 234–243. doi:10.1016/j.jamcollsurg.2010.11.001

Humphrey, S. E., Morgeson, F. P., & Mannor, M. J. (2009). Developing a theory of the strategic core of teams: A role composition model of team performance. *Journal of Applied Psychology*, *94*, 48–61. doi:10.1037/a0012997

Katz, P. (1981). Ritual in the operating room. *Ethnology*, *20*, 335-350. doi:10.2307/3773355

Klein, K. J., Ziegert, J. C., Knight, A. P., & Xiao, Y. (2006). Dynamic delegation: Shared, hierarchical, and deindividualized leadership in extreme action teams. *Administrative Science Quarterly*, *51*, 590–621. doi:10.2189/asqu.51.4.590

Kurmann, A., Tschan, F., Semmer, N. K., Seelandt, J., Candinas, D., & Beldi, G. (2012). Human factors in the operating room – The surgeon's view. *Trends in Anaesthesia and Critical Care*, *2*, 224–227. doi:10.1016/j.tacc.2012.07.007

Künzle, B., Kolbe, M., & Grote, G. (2010). Ensuring patient safety through effective leadership behaviour: A literature review. *Safety Science*, *48*, 1–17. doi:10.1016/j.ssci.2009.06.004

Künzle, B., Zala-Mezö, E., Wacker, J., Kolbe, M., Spahn, D. R., & Grote, G. (2010). Leadership in anaesthesia teams: the most effective leadership is shared. *Quality & Safety in Health Care*, *19*, 1–6. doi:10.1136/qshc.2008.030262

Lacour-Gayet, F., Clarke, D., Jacobs, J., Comas, J., Daebritz, S., Daenen, W., et al. (2004). The Aristotle score: a complexity-adjusted method to evaluate surgical results. *European Journal of Cardio-Thoracic Surgery*, *25*, 911–924. doi:10.1016/j.ejcts.2004.03.027

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*, 159-174. doi:10.2307/2529310

Luciano, M. M., Bartels, A. L., D'Innocenzo, L., Maynard, M. T., & Mathieu, J. E. (2018). Shared team experiences and team effectiveness: Unpacking the contingent effects of entrained rhythms and task characteristics. *Academy of Management Journal*, *61*, 1403–1430. doi:10.5465/amj.2016.0828

Luke, D. (2015). A user's guide to network analysis in R. *Use R!* London, England: Springer International Publishing. doi:10.1007/978-3-319-23883-8

Manser, T., Howard, S. K., & Gaba, D. M. (2008). Adaptive coordination in cardiac anaesthesia: a study of situational changes in coordination patterns using a new observation system. *Ergonomics*, *51*, 1153–1178. doi:10.1080/00140130801961919

Marks, M. A., Mathieu, J. E., & Zaccaro, S. J. (2001). A temporally based framework and taxonomy of team processes. *Academy of Management Review*, *26*, 356–376. doi:10.5465/AMR.2001.4845785

Marta, S., Leritz, L. E., & Mumford, M. D. (2005). Leadership skills and the group performance: Situational demands, behavioral requirements, and planning. *The Leadership Quarterly, 16*, 97–120. doi:10.1016/j.leaqua.2004.04.004

Maynard, M. T., Kennedy, D. M., & Sommer, S. A. (2015). Team adaptation: A fifteen-year synthesis (1998–2013) and framework for how this literature needs to "adapt" going forward. *European Journal of Work and Organizational Psychology*, *24*, 652–677. doi:10.1080/1359432x.2014.1001376

Mayo, M., Meindl, J. R., & Pastor, J. C. (2002). Shared leadership in work teams: A social network approach. In C. L. Pearce & J. A. Conger (Eds.), *Shared leadership: Reframing the hows and whys of leadership* (pp. 193–214). London:SAGE. doi:10.4135/9781452229539.n9

Mumford, T. V., Van Iddekinge, C. H., Morgeson, F. P., & Campion, M. A. (2008). The team role test: Development and validation of a team role knowledge situational judgment test. *Journal of Applied Psychology, 93,* 250–267. doi:10.1037/0021-9010.93.2.250

Nicolaides, V. C., LaPort, K. A., Chen, T. R., Tomassetti, A. J., Weis, E. J., Zaccaro, S. J., & Cortina, J. M. (2014). The shared leadership of teams: A meta-analysis of proximal, distal, and moderating relationships. *The Leadership Quarterly, 25,* 923–942. doi:10.1016/j.leaqua.2014.06.006

Parker, S. H., Flin, R., McKinley, A., & Yule, S. (2013). The surgeons' leadership inventory (SLI): a taxonomy and rating system for surgeons' intraoperative leadership skills. *The American Journal of Surgery, 205,* 745–751. doi:10.1016/j.amjsurg.2012.02.020

Pearce, C. L., & Conger, J. A. (2002). *Shared leadership: Reframing the hows and whys of leadership*. London: SAGE.

Pearce, C. L., & Manz, C. C. (2005). The new silver bullets of leadership: The importance of self-and shared leadership in knowledge work. *Organizational Dynamics, 34,* 130–140. doi:10.1016/j.orgdyn.2005.03.003

Pearce, C. L., & Sims, H. P. J. (2002). Vertical versus shared leadership as predictors of the effectiveness of change management teams: An examination of aversive, directive, transactional, transformational, and empowering leader behaviors. *Group Dynamics: Theory, Research, and Practice, 6,* 172–197. doi:10.1037//1089-2699.6.2.172

Pearsall, M. J., & Ellis, A. P. J. (2016). The effects of critical team member assertiveness on team performance and satisfaction. *Journal of Management, 32,* 575–594. doi:10.1177/0149206306289099

Rico, R., Sanchez-Manzanares, M., Gil, F., & Gibson, C. (2008). Team implicit coordination processes: A team knowledge-based approach. *Academy of Management Review, 33,* 163–184. doi:10.5465/AMR.2008.27751276

Schmutz, J., Hoffmann, F., Heimberg, E., & Manser, T. (2015). Effective coordination in medical emergency teams: The moderating role of task type. *European Journal of Work and Organizational Psychology, 24,* 761–776. doi:10.1080/1359432x.2015.1018184

Scott, J., & Carrington, P. J. (2011). The SAGE handbook of social network analysis. London: SAGE.

Shah, J., & Breazeal, C. (2010). An empirical analysis of team coordination behaviors and action planning with application to human–robot teaming. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 52,* 234–245. doi:10.1177/0018720809350882

Small, E. E., & Rentsch, J. R. (2010). Shared Leadership in Teams. *Journal of Personnel Psychology, 9,* 203–211. doi:10.1027/1866-5888/a000017

Solansky, S. T. (2008). Leadership style and team processes in self-managed teams. *Journal of Leadership & Organizational Studies, 14,* 332–341. doi: 10.1177/1548051808315549

Steiner, I. D. (1972). *Group processes and productivity*. New York, NY: Academic Press.

Stewart, G. L., Fulmer, I. S., & Barrick, M. R. (2005). An exploration of member roles as a multilevel linking mechanism for individual traits and team outcomes. *Personnel Psychology, 58,* 343–365. doi:10.1111/j.1744-6570.2005.00480.x

Summers, J. K., Humphrey, S. E., & Ferris, G. R. (2012). Team member change, flux in coordination, and performance: Effects of strategic core roles, information transfer, and cognitive ability. *Academy of Management Journal, 55,* 314–338. doi:10.5465/amj.2010.0175

Sundstrom, E., De Meuse, K. P., & Futrell, D. (1990). Work teams: Applications and effectiveness. *American Psychologist, 45*, 120–133. doi:10.1037//0003-066x.45.2.120

Tschan, F., Semmer, N. K., Gautschi, D., Hunziker, P., Spychiger, M., & Marsch, S. U. (2006). Leading to Recovery: Group Performance and Coordinative Activities in Medical Emergency Driven Groups. *Human Performance*, *19*, 277–304. doi:10.1207/s15327043hup1903_5

Vashdi, D. R., Bamberger, P. A., & Erez, M. (2013). Can Surgical Teams Ever Learn? The Role of Coordination, Complexity, and Transitivity in Action Team Learning. *Academy of Management Journal*, *56*, 945–971. doi:10.5465/amj.2010.0501

Wang, D., Waldman, D. A., & Zhang, Z. (2014). A meta-analysis of shared leadership and team effectiveness. *Journal of Applied Psychology*, *99*, 181–198. doi:10.1037/a0034531

Weingart, L. R. (1992). Impact of group goals, task component complexity, effort, and planning on group performance. *Journal of Applied Psychology, 77*, 682–693. doi:10.1037/0021-9010.77.5.682

Wood, R. E. (1986). Task complexity: Definition of the construct. *Organizational Behavior and Human Decision Processes*, *37*, 60–82. doi:10.1016/0749-5978(86)90044-0

Woods, S. A., & West, M. A. (2010). *The psychology of work and organizations*. Andover, UK: Cengage Learning EMEA.

Xiao, Y., Hunter, W. A., Mackenzie, C. F., Jefferies, N. J., Horst, R. L., & Group, L. (1996). Special section: Task complexity in emergency medical care and its implications for team coordination. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *38*, 636–645. doi:10.1518/001872096778827206

Xiao, Y., & Mackenzie, C. F. (1998). Collaboration in complex medical systems. In *Collaborative Crew Performance in Complex Operational Systems*. *NATO* Human Factors and Medicine Symposium, April 20–24. Neuilly sur Seire: NATO.

Yule, S., Flin, R., Brown, S. P., Maran, N., & Rowley, D. (2006). Development of a rating system for surgeons' non-technical skills. *Medical Education, 40*, 1098–1104. doi:10.1111/j.1365-2929.2006.02610.x

Zaccaro, S. J., Rittman, A. L., & Marks, M. A. (2001). Team leadership. *The Leadership Quarterly, 12*, 451–483. doi:10.1016/S1048-9843(01)00093-5

AUTHOR BIOGRAPHIES

Surabhi Pasarakonda is a doctoral candidate in work and organizational psychology at ETH Zurich, Switzerland. She received her MSc in Psychology from the University of Zurich, Switzerland, in 2015.

Gudela Grote is a full professor of work and organizational psychology at ETH Zurich, Switzerland. She received her PhD in industrial and organizational psychology at the Georgia Institute of Technology, Atlanta, in 1987.

Jan B. Schmutz is a senior researcher in work and organizational psychology at ETH Zurich, Switzerland. He received his PhD in industrial and organizational psychology from the University of Fribourg, Switzerland, in 2014.

Jasmina Bogdanovic was a member of the scientific staff at the Industrial Psychology and Human Factors Group within the Department of Psychology at the University of Fribourg,

Switzerland, and at the Center of Clinical Nursing Science, University Hospital Zurich, Switzerland during the time the study was conducted. Currently, she is employed by the Institute of Nursing Science at the University of Basel, Switzerland. She received her MSc in applied psychology from the University of Applied Sciences and Arts Northwestern Switzerland, Olten, Switzerland in 2012.

Merlin Guggenheim was an attending physician at the University Hospital Zurich during the time the study was conducted. Currently he is working as attending physician at SWISSPARC in Zurich, Switzerland. He received his PD in plastic reconstructive and aesthetic surgery in 2012 from the University of Zurich.

Tanja Manser was an associate professor for Human Factors and Industrial Psychology within the Department of Psychology at the University of Fribourg, Switzerland at the beginning of the study and later she was a full professor of Patient Safety at the University Hospital Bonn, Germany. Currently she is the director of the School of Applied Psychology at the University of Applied Sciences and Arts Northwestern Switzerland, Olten, Switzerland. She received her PhD in Psychology from the University of Zurich, Switzerland in 2002.