

Identifying Individual-, Team-, and Organizational-Level Factors that Affect Team Performance in Complex Domains Based on Recent Literature

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Working in teams provides several advantages to dynamic, data-driven domains, but can also add a layer of complexity to operations. There have been several reviews on teams and team performance analysis; however, there has been limited work in the last five years that has examined micro- and macro-level factors that affect overall team performance. Previous research has proposed a framework within healthcare characterizing team characteristics into three categories: individual contributions, team processes, and organizational structures. However, it is still unclear how new emerging topics in the team literature fit within this framework. Here we provide more specific definitions of the three categories proposed and conduct a review that builds on this framework by adding topics identified from the current literature. To this end, we carried out a systematic search of the human factors literature to examine the research on team performance across various domains from the past five years centered. We then propose ideas for future research on team performance.

1. INTRODUCTION

A team consists of two or more people who have defined roles and depend on each other to accomplish a shared goal (Salas et al., 1992). Now more than ever, complex, data-rich, and dynamic environments such as aviation, military operations, and healthcare depend heavily on team performance to achieve the overall system's goals and objectives (Rosen et al., 2013; Rosenman et al., 2018). Working in teams, whether in person or online, has been found to provide numerous benefits to the efficiency, accuracy, and safety of a system by combining the expertise, knowledge, and awareness of several people (Ebrahim et al., 2012; Bergiel et al., 2008). Teamwork also allows teammates to exchange ideas and identify potential solutions (Jackson et al., 2006).

One of the early reviews attempting to identify what makes an effective team separated team characteristics in healthcare into three categories (Mickan & Rodger, 2000):

- 1. **Individual contributions.** This refers to "different levels of individuals' experience and skills within teams." Factors included were, "self-knowledge, trust, commitment and flexibility."
- 2. **Team processes**. These refer to, "subtle aspects of interaction and patterns of organizing that transform input into output."
- Organizational structures. These refer to, "structural characteristics of teamwork, by referring to relatively stable procedures of coordination and control."

Although their framework was only centered on healthcare, it was among the first to identify the categories relevant to team performance. This review shows that supportive organizational structures and optimal individual contributions set the scene for effective teamwork. However, there is a lack of specificity in the categories and some topics have evolved since 2000. For example, what is meant by "trust in other team members" has now expanded to consider synthetic teammates

based on the recent literature (McNeese et al., 2017). Furthermore, the Mickan and Rodger (2000) framework should ideally be extended to settings outside of healthcare. In the 20 years that have elapsed since their paper, often the published literature focused on a specific domain as well (e.g., military environments; Goodwin et al. 2018).

It is still unclear how new emerging topics in the team literature today fit in the existing framework. Unless teamwork is carefully considered and appropriately managed, the performance of the overall system may be compromised. To this end, we provide more specific definitions of the three categories that Mickan and Rodger (2000) proposed and list factors that should be considered. The factors identified are summarized in Figure 1 below. This paper outlines the literature process that helped us develop Figure 1.

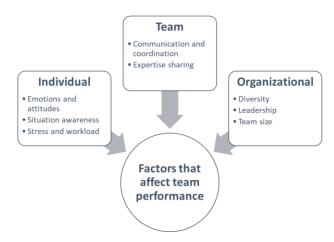


Figure 1: Proposed framework of factors that affect team performance, building from Mickan and Rodger's (2000) framework based on publications from the past five years.

2. RELATED WORK

Salas et al. (2017) presented an empirical literature review consisting of major contributions from a sample of team performance measurement literature in the past 30 years.

They defined what makes a team, identified the characteristics of an effective team, and provided 12 critical observations about team performance that help bridge the gap between research and practice. They pointed out that the context and purpose of measurement matter. This review was focused on the measurement aspect of team research and not overall team performance.

Existing reviews on team performance have largely focused on human-robot/automated/synthetic agent teaming. For example, the findings based on the literature review conducted by O'Neill et al. (2020) suggested that training human teammates on how to effectively rely upon autonomy is advantageous to overall system performance. In other reviews, Sebo et al. (2020) showed that the presence of robots as part of teams was found to increase teammates' trust in robots as well as in each other. Finally, Morrison-Smith and Ruiz (2020) highlighted the challenges experienced by virtual teams, an especially relevant topic since the onset of the COVID-19 pandemic.

Our aim is to examine the existing literature on team performance across domains to add specificity to Mickan and Rodger's (2000) framework, focusing on human-centric factors. We build on this framework by: (a) providing a specific definition of the three categories they proposed and adding specific factors that should be considered based on more recent work and (b) expanding beyond healthcare and consider other domains where overall team performance has been examined.

3. METHODOLOGY

Relevant papers were identified for this literature review using the guidelines proposed by Kitchenham and Charters (2007) and Kitchenham and Brereton (2013) for performing systematic literature reviews.

Step 1: Planning the review

We first specified our search strategy, including inclusion and exclusion criteria. The selection criteria required studies to be written in English, peer-reviewed journal articles or conference proceedings, and published in 2016 or after to be included in this review. Note that 2016 was selected as a cutoff date to focus on emerging topics and developments from the past five years. The search terms included: team, teamwork, pairs, and performance.

The generated search terms were used to conduct searches using Google Scholar, ResearchGate, Science Direct, Academia.edu, and the ACM digital library. To be included in this review, the studies had to address at least one of the research questions below:

- 1. What are the domains and tasks that researchers have studied team performance in?
- 2. What are the factors that affect team performance at the individual-level, team-level, and organizational-level?

Step 2: Conducting the review

The initial search yielded 200 potential papers. After applying all inclusion and exclusion criteria, 18 papers met the requirements of this review. Relevant papers were used to generate additional searches via a 'snowballing effect'; i.e., using the reference list of each relevant paper to identify other related work. This process helped us identify 12 additional papers that met the selection criteria. Ultimately 30 papers were included in this review.

For each paper, we made note of the setup of the experiment, the domain of each experiment, and the size of the teams studied. Building on the framework of Mickan and Rodger (2000), we identified factors that affect team performance and assigned them to one of three categories: individual-, team-, or organizational-level factors and these are described as follows:

- Individual-level factors. These relate to an individual teammate, such as personal characteristics, attitudes, emotions, and each member's physical and cognitive abilities.
- **Team-level factors.** These refer to the control or decision-making of a team when collaborating on a task.
- Organizational-level factors. These are factors
 outside of the control of a team and relate mainly to
 the decisions taken by management before the start of
 the experiment or the activity carried out in teams.

4. RESULTS

Domains and Tasks

The domains covered by the 30 studies as part of this review included the following: academia (20%), healthcare (17%), industry (40%), military operations (13%), and public safety (10%). The public safety domain includes the command-and-control environment of police officers (e.g., Daggett et al., 2016) and firefighters (Hamilton et al., 2017). In the military domain, researchers have studied teamwork among controllers of unmanned aerial vehicles (UAVs; e.g., Devlin et al., 2020), submarine crews (Gorman et al., 2019), and other military operations, such as border security and control (Meslec et al., 2020). Within healthcare, teamwork has been studied both with physicians (Jamshed et al., 2018) and with nurses (Sonoda et al., 2018). Academia has examined research and development teams (e.g., Li et al., 2018), the interaction between master's degree and Ph.D. holders (Sanyal & Hisam, 2018), and how teammates coordinate while working on a group project (Paul et al., 2016). Finally, within industry, team performance was explored in banking (Lee & Wong, 2017), construction (Meneghel et al., 2016), entrepreneurship (Hasan & Koning, 2019), hotel management (Li et al., 2018), information technology (e.g., Gyanchandani, 2017), manufacturing (Ji & Yan, 2020), office work (Hoogeboom & Wilderom, 2019), and software development (e.g., D'Angelo & Begel, 2017).

Factors that Affect Team Performance

Individual-level factors. Based on the review of recent work, we have found emotions, attitudes, situation awareness, stress, and workload to be current topics of interest.

Emotions and attitudes. Lin et al. (2017) illustrated that a positive team affective tone is positively associated with team performance, and vice versa. Moreover, Meneghel et al. (2016) first explained how positive emotions are disseminated among team members and the importance of such a process. The experimenters then showed that collective positive emotions among team members allowed them to broaden the scope of their thinking and develop positive meaning amidst challenges. Furthermore, Lee & Wong (2017) found that as emotional intelligence between teammates increases, task conflicts between them decreased. More recent studies showed that teams with higher average levels of individual emotional intelligence performed better than those with lower levels (Michinov & Michinov, 2020).

Situation awareness (SA). SA is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status (Endsley, 1988). Hamilton et al. (2017) suggested that it is always important to have the necessary individual SA to complete a task, but there are times in which aspects of SA in relation to judgments or feelings should be low or unexpressed in order to create the necessary drive to regulate one's behavior. In other words, there are times in which it is better to be skilled and unaware as opposed to being both skilled and aware. On the other hand, McNeese et al. (2017) also examined SA, but with the presence or absence of a synthetic teammate as part of a group of three. They found that synthetic teams performed as well at the mission levels as all-human teams but processed targets less efficiently. The results reflected the weakness of the synthetic teammate when it comes to team SA and coordination strategies.

Workload and stress. Researchers have found that there is a relationship between stress and workload. Namely, that both physical and mental workload tend to cause more stress in larger teams as compared to smaller teams, and this subsequently results in more mistakes made by the team and deterioration in the teams' overall performances (Galdikiene et al., 2016). Within healthcare, Sonoda et al. (2018), for instance, showed that the mental stress experienced by circulating nurses affected their sense of teamwork performance.

Team-level factors. This category refers to the control or decision-making of a team when collaborating on a task such as team communication, coordination, and expertise sharing.

Communication and coordination. Team effectiveness is defined as not only perceived satisfaction of the needs of individual team members, but also the quality of the team's outcomes (Hackman, 1990; Weimar et al., 2017). Daggett et al. (2016) showed that teams that were more effective at face-to-face verbal communication and system interaction performed better at information discovery tasks and had more accurate game decisions. Moreover, D'Angelo & Begel (2017)

confirmed that teams performed significantly better when communicating with verbal and gestural references. Pairs sometimes must use many references to coordinate with their partners about a specific location in their code, often referring to line numbers. This study showed that pairs who communicated using references were faster and more successful at responding to those references, suggesting it is a useful aid for coordination. Other studies showed that tacit coordination resulted in better performance than explicit verbal communication (Kim et al., 2017). However, Hoogeboom and Wilderom (2019) illustrated that the high frequency of recurring team communication reduces the sharing of information among team members, especially in non-routine task contexts, thereby lowering team performance.

Knowledge and expertise sharing. There is a growing body of studies that encourages team members to share their expertise because it has been found to team performance within healthcare (Jamshed et al., 2018). Olaisen and Revang (2017) also showed that knowledge sharing strengthens the possibility for future collaboration and innovations both on an individual- and team-level.

Organizational-level factors. This category includes factors relating to the team setup and structure such as team diversity, leadership, and team size. Ji and Yan (2020) found that team structure can improve team coordination.

Diversity. Experimenters also found that collective intelligence—i.e., a team's ability to perform a wide variety of tasks—is positively correlated with the presence of a female team member (Kim et al., 2017). Garcia Martinez et al. (2017) also tested diversity within the team structure and their findings suggest that diversity is a valuable strategy for an organization to pursue as it provides greater cognitive ability. However, their research highlights that high diversity in gender or skills can also deteriorate performance.

Leadership. Recent studies suggest that teams usually employ structural elements to guide or coordinate their work. For instance, managers are likely to elect a leader to monitor individual team member work, divide collective work among team members, and set rules or procedures for teamwork, including deadlines for tasks (Meyer et al., 2017). Research shows a strong connection between different leadership and team performance (Chiniara & Bentein, 2018; Li et al., 2018). For instance, Chiniara and Bentein (2018) showed that servant leaders' focus on serving individuals, by placing the good of the employees over their self-interests, improves the collective team performance. Moreover, Gyanchandani (2017) illustrates that transformational leaders who share their visions and ideas with team members make teams more effective and yield a higher level of member satisfaction.

Team Size. In the literature, participants have typically been recruited and divided into teams of different sizes, depending on the domain. Teamwork could involve as little as two (D'Angelo & Begel, 2017; Devlin et al., 2020) or three (McNeese et al., 2017) people, and as many as 40 (Garcia Martinez et al., 2017). Salas et al. (2017) showed that, when it comes to performance, the size of the team matters as having more teammates can reduce performance.

5. DISCUSSION

The main objective of this literature review was to examine the most recent research on team performance across domains to add specificity to the Mickan and Rodger's (2000) framework. We sought to address two research questions centered around: (1) identifying domains where team performance has been examined, and (2) specific factors that affect team performance at the individual-level, team-level, and organizational-level. The literature from the past five years have added greater specificity to Mickan and Rodger's (2000) framework.

Overall, the review shows that team performance is studied in various different domains. Based on this review, there has been a recent interest in examining teams within healthcare. This reflects the increased focus on healthcare in the past years, something that has only been accentuated by the COVID-19 pandemic. The review also suggests that there is a need for more research within public safety, i.e., the protection of the general public, which only accounted for 10% of the literature and is a growing domain of interest. In general, teams have been largely studied within a specific domain. As a result, it is unclear whether the results found in one domain may not apply in another domain. For example, we saw that D'Angelo and Begel's (2017) findings during a code clean-up showed that pairs who communicated using references were more successful to responding to those references and suggested it is a useful aid for coordination. However, more research is needed to understand whether this applies to more complicated systems like aviation or healthcare. There is a need to systematically examine team factors across domains.

The **individual-level factors** identified centered around how team members must simultaneously acknowledge and value their contribution to the team. The findings from the literature review suggest that with sufficient self-knowledge, teammates can then respect and trust their teammates' individual contributions. Through training and individual coaching, team members can learn how to constructively give feedback and express opinions and emotions to limit conflicts (Lee & Wong, 2017). This in turn has positive effects on team effectiveness.

Team-level factors that are of interest in recent years examine aspects that affect performance have centered around effective communication and coordination structures. This is especially true in complex, dynamic environments where teams need to respond quickly while maintaining shared cognition of the situation, such as emergency landings in aviation or life-threatening complications in surgery. The findings from this literature review suggest that teammates share knowledge, but training may be needed to determine what information to share and how to describe what they know (Olaisen & Revang, 2017).

This review also sheds light on **organizational-level factors**, i.e., ones that relate to the decisions taken by management to set up and structure teams per our definition. The findings of this review provide practical implications on how to structure a team to facilitate collective decision-making and the development of team situation awareness. The results show positive effects of diversity in expertise, background, and gender on team performance and innovation. Sharing, processing, and integrating diverse approaches to problem solving in team members' expertise and background positively impact innovation novelty. However, there has been other work that shows that too much diversity could lead to less than desirable outcomes (Garcia Martinez et al., 2017).

This review has also revealed three general future research directions:

- How teams adapt to changing workload over time in complex environments. There has been growing interest in understanding how teams deal with data overload and how teams adapt. There has been limited research on how teammates react to high physical and cognitive workload conditions (e.g., cognitive redline; Sonoda et al., 2018) or how these reactions change over time (Devlin et al., 2020). More work is needed to understand how the different individual-, team-, and organizational-level factors interact with high workload to affect team performance and whether the redistribution of tasks in such situations has positive effects on a team's performance.
- What makes an effective team leader. Based on the findings of this review, team leaders play an important role in developing overall team emotional intelligence as team leader's emotional intelligence has a positive effect on team emotional intelligence (Wong & Law, 2017). Managers and practitioners should then consider the importance of individual emotional intelligence when setting up a team. Moreover, they must implement training programs for both team members and leaders on understanding and dealing with emotions, so they learn how to interact when subject to complex time-sensitive tasks (Van der Hoek et al., 2018).
- How to build effective teams. Future work should address the ongoing research challenge of how to build effective teams from setting one up to the overall structure of larger teams. For instance, whether experts are best suited working with other experts or novices and how experts should share their knowledge (Jamshed et al., 2018). Currently, there is limited guidance on how to structure a team as a function of task, location, and communication strategies.

6. REFERENCES

- Bergiel, B. J., Bergiel, E. B., & Balsmeier, P. W. (2008). Nature of virtual teams: a summary of their advantages and disadvantages. *Management research news*.
- Chiniara, M., & Bentein, K. (2018). The servant leadership advantage: When perceiving low differentiation in leader-member relationship quality influences team cohesion, team task performance and service OCB. The Leadership Quarterly, 29(2), 333-345.
- Daggett, M., O'Brien, K., Hurley, M., Hannon, D. (2016). Predicting Team Performance Through Human Behavioral Sensing and Quantitative Workflow Instrumentation. Advances in Human Factors and System Interactions Advances in Intelligent Systems and Computing, 245-258.
- D'Angelo, S., & Begel, A. (2017). Improving Communication Between Pair Programmers Using Shared Gaze Awareness. Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems.
- Devlin, S. P., Flynn, J. R., Riggs, S. L. (2020). How Shared Visual Attention Patterns of Pairs Unfold Over Time when Workload Changes. ACM Symposium on Eye Tracking Research and Applications.
- Ebrahim, N. A., Rashid, S. H. A., Ahmed, S., & Taha, Z. (2012). The effectiveness of virtual R&D teams in SMEs: experiences of Malaysian SMEs. *arXiv preprint arXiv:1207.6832*.
- Endsley, M. R. (1988). Design and Evaluation for Situation Awareness Enhancement. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 32(2), 97–101.
- Garcia Martinez, M., Zouaghi, F., & Garcia Marco, T. (2017). Diversity is strategy: the effect of R&D team diversity on innovative performance. *R&D Management*, 47(2), 311-329.
- Goodwin, G. F., Blacksmith, N., & Coats, M. R. (2018). The science of teams in the military: Contributions from over 60 years of research. *American Psychologist*, 73(4), 322.
- Gorman, J. C., Grimm, D. A., Stevens, R. H., Galloway, T., Willemsen-Dunlap, A. M., Halpin, D. J. (2019). Measuring Real-Time Team Cognition During Team Training. Human Factors: The Journal of the Human Factors and Ergonomics Society, 62(5), 825-860.
- Gyanchandani, R. (2017). The effect of transformational leadership style on team performance in IT sector. IUP Journal of Soft Skills, 11(3), 29-44.
- Hamilton, K., Mancuso, V., Mohammed, S., Tesler, R., & McNeese, M. (2017). Skilled and unaware: The interactive effects of team cognition, team metacognition, and task confidence on team performance. *Journal of Cognitive Engineering and Decision Making*, 11(4), 382-395.
- Hasan, S., & Koning, R. (2019). Prior ties and the limits of peer effects on startup team performance. *Strategic Management Journal*, 40(9), 1394-1416.
- Hoogeboom, M. A., & Wilderom, C. P. (2019). A Complex Adaptive Systems Approach to Real-Life Team Interaction Patterns, Task Context, Information Sharing, and Effectiveness. Group; Organization Management, 45(1), 3-42.
- Jackson, S. E., Chuang, C. H., Harden, E. E., & Jiang, Y. (2006). Toward developing human resource management systems for knowledge-intensive teamwork. In *Research in personnel and human resources management*. Emerald Group Publishing Limited.
- Jamshed, S., Nazri, M., Abu Bakar, R., & Majeed, N. (2018). The Effect of Knowledge Sharing on Team Performance through Lens of Team Culture. Oman Chapter of Arabian Journal of Business and Management Review, 34(6112), 1-17.
- Ji, H., & Yan, J. (2020). How Team Structure Can Enhance Performance: Team Longevity's Moderating Effect and Team Coordination's Mediating Effect. Frontiers in Psychology, 11, 1873.
- Kim, Y. J., Engel, D., Woolley, A. W., Lin, J., Mcarthur, N.; Malone, T. W. (2017). What Makes a Strong Team? Collective Intelligence Predicts Team Performance in League of Legends. Academy of Management Proceedings, 2016(1), 13564.
- Kitchenham B, Brereton P (2013) A systematic review of systematic review process research in software engineering. Inf Softw Technol 55(12):2049– 2075.
- Kitchenham B, Charters S (2007) Guidelines for performing systematic literature reviews in software engineering version 2.3. Engineering 45(4ve):1051.

- Lee, C., and Wong, C. S. (2017). The effect of team emotional intelligence on team process and effectiveness. J. Manag. Organ. 25, 844–859.
- Li, G., Rubenstein, A. L., Lin, W., Wang, M., & Chen, X. (2018). The curvilinear effect of benevolent leadership on team performance: The mediating role of team action processes and the moderating role of team commitment. Personnel Psychology, 71(3), 369-397.
- Lin, C. P., He, H., Baruch, Y., & Ashforth, B. E. (2017). The effect of team affective tone on team performance: The roles of team identification and team cooperation. Human Resource Management, 56(6), 931-952.
- McNeese, N. J., Demir, M., Cooke, N. J., & Myers, C. (2017). Teaming With a Synthetic Teammate: Insights into Human-Autonomy Teaming. Human Factors: The Journal of the Human Factors and Ergonomics Society, 60(2), 262-273.
- Meneghel, I., Salanova, M., & Martínez, I. M. (2016). Feeling good makes us stronger: How team resilience mediates the effect of positive emotions on team performance. Journal of Happiness Studies, 17(1), 239-255.
- Meslec, N., Duel, J., & Soeters, J. (2020). The role of teamwork on team performance in extreme military environments: an empirical study. *Team Performance Management: An International Journal*.
- Michinov, E., & Michinov, N. (2020). When emotional intelligence predicts team performance: Further validation of the short version of the Workgroup Emotional Intelligence Profile. *Current Psychology*, 1-14.
- Mickan, S., & Rodger, S. (2000). Characteristics of effective teams: a literature review. *Australian Health Review*, 23(3), 201-208.
- M. J. Keith, G. Anderson, J. Gaskin, and D. L. Dean (2018), "Team Video Gaming for Team Building: Effects on Team Performance," AIS Transactions on Human Computer Interaction, Vol. 10, pp. 205-231, 2018.
- Morrison-Smith, S., & Ruiz, J. (2020). Challenges and barriers in virtual teams: a literature review. *SN Applied Sciences*, *2*, 1-33.
- Olaisen, J., & Revang, O. (2017). Working smarter and greener: Collaborative knowledge sharing in virtual global project teams. *International Journal of Information Management*, 37(1), 1441-1448.
- O'Neill, T., McNeese, N., Barron, A., & Schelble, B. (2020). Human—Autonomy Teaming: A Review and Analysis of the Empirical Literature. *Human Factors*, 0018720820960865.
- Paul, R., Drake, J. R., & Liang, H. (2016). Global virtual team performance: The effect of coordination effectiveness, trust, and team cohesion. IEEE Transactions on Professional Communication, 59(3), 186-202.
- Rosen, M. A., Schiebel, N., Salas, E., Wu, T., Silvestri, S., & King, H. (2013). How can team performance be measured, assessed, and diagnosed. In E. Salas & K. Frush (Eds.), Improving patient safety through teamwork and team training (pp. 59–79). New York, NY, USA: Oxford University Press.
- Rosenman, E. D., Dixon, A. J., Webb, J. M., Brolliar, S., Golden, S. J., Jones, K. A., & Fernandez, R. (2018). A simulation-based approach to measuring team situational awareness in emergency medicine: a multicenter, observational study. *Academic Emergency Medicine*, 25(2), 196-204.
- Salas, E., Dickinson, T. L., Converse, S. A., & Tannenbaum, S. I. (1992). Toward an understanding of team performance and training.
- Salas, E., Reyes, D. L., & Woods, A. L. (2017). The assessment of team performance: Observations and needs. In *Innovative assessment of collaboration* (pp. 21-36). Springer, Cham.
- Sanyal, S., & Hisam, M. W. (2018). The impact of teamwork on work performance of employees: A study of faculty members in Dhofar University. *IOSR Journal of Business and Management*, 20(3), 15-22.
- Sebo, S., Stoll, B., Scassellati, B., & Jung, M. F. (2020). Robots in groups and teams: a literature review. *Proceedings of the ACM on Human-Computer Interaction*, 4(CSCW2), 1-36.
- Sonoda, Y., Onozuka, D., & Hagihara, A. (2018). Factors related to teamwork performance and stress of operating room nurses. Journal of nursing management, 26(1), 66-73.
- Van der Hoek, M., Groeneveld, S., & Kuipers, B. (2018). Goal setting in teams: Goal clarity and team performance in the public sector. Review of public personnel administration, 38(4), 472-493.
- Weimar, E., Nugroho, A., Visser, J., Plaat, A., Goudbeek, M., & Schouten, A. P. (2017). The influence of teamwork quality on software team performance. arXiv preprint arXiv:1701.06146.
- Wong, C. S., & Law, K. S. (2017). The effects of leader and follower emotional intelligence on performance and attitude: An exploratory study. In *Leadership Perspectives* (pp. 97-128). Routledge.