The cognitive underpinnings of effective teamwork: a continuation

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Abstract

Purpose – Team cognition is known to be an important predictor of team process and performance. DeChurch and Mesmer-Magnus (2010) reported the results of an extensive meta-analytic examination into the role of team cognition in team process and performance, and documented the unique contribution of team cognition to these outcomes while controlling for the motivational dynamics of the team. Research on team cognition has exploded since the publication of DeChurch and Mesmer-Magnus' meta-analysis, which raises the question: to what extent do the effect sizes reported in their 2010 meta-analysis still hold with the inclusion of newly published research? The paper aims to discuss this issue.

Design/methodology/approach – The authors updated DeChurch and Mesmer-Magnus' meta-analytic database with newly published studies, nearly doubling its size, and reran their original analyses examining the role of team cognition in team process and performance.

Findings – Overall, results show consistent effects for team cognition in team process and performance. However, whereas originally compilational cognition was more strongly related to both team process and team performance than was compositional cognition, in the updated database, compilational cognition is more strongly related to team process and compositional cognition is more strongly related to team performance.

Originality/value – Meta-analyses are only as generalizable as the databases they are comprised of. Periodic updates are necessary to incorporate newly published studies and confirm that prior findings still hold. This study confirms that the findings of DeChurch and Mesmer-Magnus' (2010) team cognition meta-analysis continue to generalize to today's teams.

Keywords Meta-analysis, Team performance, Team cognition, Team process

Paper type Research paper

Over the last several decades, the most impressive and innovative solutions have been the product of teamwork, and the prevalence of teamwork in today's workplaces has steadily increased. Furthermore, teamwork has become more technologically sophisticated and geographically and temporally distributed. For example, customer service teams are employing a "follow the sun" approach, whereby teams pass work around the globe for a continuous stream of effort without anyone working overnight (Maznevski and Chudoba, 2000), and Pixar animation teams have become the leading name in computer animation without ever buying an outside script (Catmull, 2008). Not surprisingly, due to the increasing technological sophistication and globalization of today's economy, many would argue that teamwork is necessary for nearly all innovations (Jones, 2009; Wuchty *et al.*, 2007). With the enhanced reliance on teamwork in the workplace, researchers have sought to understand the predictors of team behavior and success.

One of the most well-studied predictors of effective team behavior and successful team performance is team cognition (DeChurch and Mesmer-Magnus, 2010). Team cognition refers to cognitive structures or knowledge representations that help members of a team

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efficiently and effectively organize and execute tasks toward achieving the team's goal or goals (Kozlowski and Ilgen, 2006). The team cognition concept was first identified by Cannon-Bowers and Salas (1990) when they observed that expert teams were able to coordinate their effort without having to communicate directly with one another. Further exploration of this phenomenon found that teams who shared an understanding of the task, team, or knowledge distribution within the team were more efficient and effective than teams that did not have this understanding. Further research confirmed the idea proposed by Cannon-Bowers and Salas (1990) that cognitive emergent states are indeed key determinants in team functioning overall (Converse *et al.*, 1991; DeChurch and Mesmer-Magnus, 2010: Marks *et al.*, 2002; Mathieu *et al.*, 2000; Wegner, 1987), and in team behavioral process (Kozlowski and Ilgen, 2006; Mathieu *et al.*, 2000; Stout *et al.*, 1999), and team performance in particular (Austin, 2003; Hollingshead, 1998; Kang *et al.*, 2006; Marks *et al.*, 2002; Mathieu *et al.*, 2000).

In their 2010 meta-analytic review of team cognition, DeChurch and Mesmer-Magnus compiled the results of 65 independent studies ($n = 3,738$) to conclude that team cognition explained approximately 18 percent of the variance in team behavioral process and approximately 14 percent of the variance in team performance. Due to its lasting positive relationship with team process and performance, research on team cognition has become even more prevalent in the extant literature in the years since their 2010 meta-analytic integration. Indeed, since the publication of DeChurch and Mesmer-Magnus' meta-analysis of team cognition, the extant empirical literature on team cognition has nearly doubled in size. Given the explosion of research in this area, along with the relative importance placed on the effect sizes reported in the DeChurch and Mesmer-Magnus' meta-analysis of team cognition, an update of their findings is warranted to ensure that what we know about team cognition's role in team process and performance still holds (Ones *et al.*, 2017). Such a replication is our purpose in this manuscript.

The team cognition construct

Over the course of their extensive review of the team cognition literature, DeChurch and Mesmer-Magnus (2010) identified more than 50 terms that have been used to refer to various operationalizations of team cognition within the extant literature (including accuracy of knowledge identification, collective knowledge, directory updating, location of expertise, shared mental models (SMMs), perceptions of accurate cognitive map, task coordination, and transactive memory system (TMS), among others). By carefully analyzing the conceptual structure of these various operationalizations of team cognition, DeChurch and Mesmer-Magnus identified and described two of the most common operationalizations of team cognition that are studied in the extant literature: SMMs and TMSs. SMMs are mental representations that team members hold about themselves and the task, and how the team works toward the task in their environment (Cannon-Bowers *et al.*, 1993; Klimoski and Mohammed, 1994). For example, if a sales team is working to improve their profits and all team members view the same minimum number as "success," this would represent part of an SMM. By having the same definition of objective success, the team can work toward this goal without any roadblocks; everyone understands the goal. Similarly, if a marketing team is working to improve a previously ineffective marketing strategy, each member must understand the goals and most effective strategies for accomplishing their task. By sharing this understanding through an SMM, the team is more likely to be successful in their team process and output.

TMSs refer to the mental representations held by members that summarize the unique information possessed by each member and an awareness of others' knowledge in the group (DeChurch and Mesmer-Magnus, 2010). An example of a TMS would be if Member A of our sales team is aware that Member B collected the latest profit numbers.

By understanding Member B's expertise, Member A can communicate and exchange information more efficiently in the team (Lewis, 2004; Peltokorpi, 2008). Another example of a TMS could be a design team, wherein Member A is known as the expert on user-interface problems and Member B is known as the expert on hardware issues. By knowing the expertise of each team member, team process becomes more efficient and successful team performance is ensured. Importantly, the team cognition construct is more complex than simply comparing SMM or TMS. In their review of the cognition literature, DeChurch and Mesmer-Magnus (2010) organized the various operationalizations of team cognition along dimensions that better delineated their content as well as how they were conceptualized: form of cognition, nature of emergence, and content of cognition. Sorting the literature in this way allowed them to do a more focused exploration into the role of cognition in team process and performance.

Form of cognition refers to the form or manner in which cognitive information is elicited. The two main forms of cognition represented in the literature are perceptual and structured (Rentsch *et al.*, 2008). Perceptual cognition captures people's beliefs, attitudes, and expectations about the cognition of the team or of the individual (Rentsch *et al.*, 2008, p. 146). For instance, the measure of TMSs developed by Kyle Lewis (2003) measures an individual's beliefs about the specialization, credibility, and coordination of the team using rating scales, but it does not attempt to model how the knowledge is actually structured. Conversely, structured forms of cognition aim to capture the patterns of knowledge in a team and assess sharedness of cognition by investigating the similarity of teammates' networks. Whereas perceptual forms of cognition use rating scales that are scored for similarity, accuracy, or overall effectiveness, structured forms of cognition commonly use pairwise comparisons (Mathieu *et al.*, 2005) and concept mapping (Murase *et al.*, 2014), which then get analyzed with programs such as Pathfinder, network analysis, and computational modeling.

With regard to nature of emergence, team cognition is described as a bottom-up emergent state that originates in individuals and emerges as a pattern at the team level (Kozlowski and Klein, 2000). According to Kozlowski and Klein, emergence can take different forms, ranging from compositional emergence (where the construct at the team level resembles that at the individual level in terms of form and function) to compilational emergence (where the team level construct is different in form from the individual level). We differentiate between compositional and compilational emergence using an indirect investigation of the nature of emergence (Kozlowski and Bell, 2013). SMMs are theorized to emerge as a compositional construct because the same content is shared amongst individuals (Cannon-Bowers and Salas, 2001). For instance in Mathieu *et al.* (2005), SMMs are measured using pairwise comparisons where participants' conceptualizations of key task- and team-work attributes are compared, whereas TMSs are theorized to emerge as a network of individuals with distinct knowledge and an awareness of who knows what (Peltokorpi, 2008), so the nature of emergence is compilational. Many of the extant studies on TMSs measure the construct using the survey designed by Kyle Lewis (2003), which elicits perceptions about the credibility, coordination, and specialization of the system.

Finally, a third important delineation of the shared cognition construct is the content of the cognition. Cannon-Bowers and Salas (2001) initially proposed four categories of shared cognition content: equipment model, task model, team model, and interaction model. However Mohammed *et al.* (2010) observed that literature has tended to collapse mental models into two areas: teamwork, or cognition about the team, and taskwork, or cognition about the task. Teamwork mental models get at knowledge of intra-personal processes, how team members interact, and how goals overlap or connect. Taskwork mental models reference aspects of the task or equipment, such as what needs to be done when, and how are aspects of the task related to one another. These aspects are typically derived using a detailed task analysis. For instance, Ayoko and Chua (2014) elicited taskwork mental models from servicemen in combat teams by asking them to rate the relatedness of statements about the equipment, procedures, and task. Ayoko and Chua used the same procedure for the teamwork mental model except the statements concerned team interaction processes and team characteristics.

The role of team cognition in team process and performance

Understanding the different forms and types of team cognition content, emergence, and measurement is an important step to estimating the effect of team cognition on team outcomes. Although shared cognition among team members creates a positive climate for teamwork and is known to predict team trust and collective efficacy (Cannon-Bowers and Salas, 2001; DeChurch and Mesmer-Magnus, 2010), team cognition is particularly influential to the underlying behavioral processes that are the makeup of teamwork. Empirical studies have documented the reciprocal relationship between behavioral processes and shared cognition (Mathieu *et al.*, 2000; Stout *et al.*, 1999). Team cognition theories such as those of SMMs give us an explanation of how SMMs among team members can help teams adapt more efficiently to new tasks and challenges because of their shared understanding of fellow team members' knowledge strengths (Cannon-Bowers *et al.*, 1995; Mathieu *et al.*, 2000). In a study conducted by Kanki and Foushee (1989), history of flying together was found to contribute to a flight crew's overall cognition and communication skills, underscoring the link between team cognition and process. The findings of such studies suggest that shared and/or complementary team cognition can act as a supportive structure for informing the behaviors of team members.

Team cognition is also known to be an important precursor to team performance, both directly and indirectly through improved team process. Team cognition can positively influence behavioral processes that aid in the ability of a team to successfully think on its feet or to adapt quickly and efficiently to a changing team environment (Entin and Serfaty, 1999). With an enhanced efficiency in team functioning, there often comes an increase in a team's overall performance (Stout *et al.*, 1999). Team cognition also has a direct impact on performance. Austin (2003) studied TMSs in a large apparel and sporting goods company, and found that task and external relationship TMSs were positively and significantly related to group performance outcomes.

In their 2010 study, DeChurch and Mesmer-Magnus meta-analyzed the role of team cognition in process and performance by first organizing team cognition into the overarching dimensions of cognition, and then analyzing the unique role of each dimension in team process and performance. They found stronger positive relationships with team process and performance for compilational (rather than compositional) emergence, structured (rather than perceptual) compositional cognition, structured team-based cognition, and perceptual task-based cognition. Next, using meta-regression analysis, they indexed the role of cognition in process and performance over and above what could be predicted by another historically relevant construct-team cohesion (Mathieu *et al.*, 2008). In particular, team cohesion is known to influence the efficiency of team processes such as team coordination and communication, and ultimately team success, because members of more cohesive teams feel more emotionally connected to and satisfied with their team and are willing to work harder on its behalf (Barrick *et al.*, 2007; McGrath, 1984; O'Reilly *et al.*, 1989; Srivastava *et al.*, 2006). DeChurch and Mesmer-Magnus (2010) found that team cognition explains significant incremental variance in both outcomes even after controlling for the effects of the motivational dynamics of the team. Results indicated that team cognition explained an additional 7 percent of the variance in team performance over and above that which can be explained by team cohesion and team process.

Method

This manuscript reports the results of an update to DeChurch and Mesmer-Magnus' (2010) meta-analysis of the role of team cognition in team process and performance. We replicated the analyses using an updated sample of studies of team cognition. Their original sample was comprised of 65 independent studies (reporting results gleaned from 3,738 groups and approximately 18,240 individuals). Our updated database was nearly twice the size of the original database, and includes findings from 128 independent studies reporting results from 4,943 teams (total approximately 19,575 individuals). To build our database, we began with DeChurch and Mesmer-Magnus' (2010) comprehensive database of the team cognition literature, and replicated their original search strategy to identify studies published since the completion of their database. In accordance with their original search strategy, we conducted a comprehensive search of the PsycInfo, ABI Inform, and Google Scholar databases using relevant keywords/phrases (e.g. group OR team AND cognition, mental models, shared cognition, transactive memory, schemas, knowledge structure, cognitive structure, cognitive map, conceptual framework, and shared situation awareness). In addition, we manually searched the references cited in studies that were identified as relevant to the constructs of interest. We used multiple databases and snowballed our reference lists in order to compile the most complete database possible (Ones *et al.*, 2017). In order to be included in the meta-analytic database, studies must have examined team cognition in relation to either team process or team performance, and reported sufficient information in which to compute a bivariate correlation between team cognition and the relevant outcome. A list of the studies included in the meta-analytic database is available upon request.

Coding content and procedure

In addition to coding the conceptualizations of team cognition and outcome constructs, each article was coded for sample size, number of teams, sample type (e.g. teams of nurses, military/police, engineers, air traffic controllers, and students), and team task (e.g. criminal investigation, medical simulation, case analyses, and project design). Each article was coded by at least two authors to ensure coding reliability and validity. Initial coder reliability was high ($\kappa = 0.96$). Instances of coder disagreement were resolved through discussion.

Team cognition. We coded the nature of team cognitive emergence (compositional vs compilational) as well as the content of the team's cognition (task-related vs team-related). The nature of emergence of expresses the way cognition of individuals within a team manifests as a pattern (Kozlowski and Klein, 2000), and was coded as either compositional or compilational. Compositional cognition is characterized by either congruence (the degree to which members' mental models match) or accuracy (the degree to which the members' mental models matched a "true score" like that of an expert's mental model) of the team's cognition. Compilational cognition refers to the extent to which team members possess complementary task- or team-relevant knowledge as with TMSs. The content of team cognition expresses the content domains of cognition, including task-related cognition (e.g. features of the team's job, major task duties, equipment, etc.) and team-related cognition (e.g. features of how team members interact and are interdependent with one another). Content of cognition was coded as task when cognition was centered around the nature and components of the task, and as team when cognition was centered around team members' roles, responsibilities, and interactions with one another.

Team process. We coded team process as incidents of behavioral process, which would include transition processes (e.g. evaluating or planning activities, goal specification, strategy formulation, etc.), action processes (e.g. actions toward goal accomplishment, monitoring progress toward goals, coordination, etc.), and processes wherein transition and action were both assessed (Marks *et al.*, 2001).

Team performance. Team performance was operationalized as task performance, completion, or proficiency. Some examples of performance include population count at the end of a disaster simulation (e.g. Resick *et al.*, 2010), assessments of team level of effort in planning and scheduling tasks, supervisor or client ratings of work quality (e.g. Mohammed and Nadkarni, 2014), and final team score following completion of a distributed dynamic decision-making simulation (e.g. Pearsall *et al.*, 2009).

Analysis

We used the meta-analytic methods outlined by Hunter and Schmidt (2014). Because reliability estimates for team cognition and its relevant correlates were not reported in all studies, corrections to reliability were performed using artifact distribution meta-analysis. As in DeChurch and Mesmer-Magnus (2010), our objective was to generalize across both time and measures. As such, we included estimates of both test-retest reliability (coefficient of stability) and internal consistency (coefficient of equivalence) in creating our artifact distributions (Hunter and Schmidt, 2004). For the meta-analytic regression, we conducted regression analyses on the meta-analytically derived correlations between the key variables. We used harmonic means of the total sample sizes on which each meta-analytic correlation from the input matrix was estimated to compute the standard errors associated with the regression coefficients (cf. Viswesvaran and Ones, 1995).

Results

Tables I-IV present meta-analytic results for the role of team cognition in team process and performance. In these tables, we report the number of correlations meta-analyzed (k), number of teams (n), the sample size weighted mean observed correlation (r), the standard deviation of r (SD_r), the sample size mean observed correlation corrected for unreliability in the predictor and criterion (ρ), the standard deviation of ρ (SD_ρ), the 80 percent credibility

Table I.
Overview of team cognition

Meta-analysis	k	n	r	SD_r	ρ	SD_ρ	80%CV	95%CI	%ARTV
Team behavioral process	44	2,973	0.32	0.18	0.38	0.16	0.17-0.59	0.32-0.44	38.93
Team performance	107	7,775	0.30	0.17	0.35	0.15	0.16-0.55	0.31-0.39	41.79

Notes: k, number of correlations meta-analyzed; n, total number of groups; r, sample size weighted mean observed correlation; SD_r, sample size weighted standard deviation of the observed correlations; ρ, sample size weighted mean observed correlation corrected for unreliability in both measures; SD_ρ, standard deviation of ρ; 80%CV, 80 percent credibility interval around ρ; 95%CI, 95% confidence interval around ρ; %SEV, percent variance due to sampling error; %ARTV, percent variance due to all corrected artifacts

Table II.
Nature of team cognition emergence as a moderator of the cognition-process and cognition-performance relationships

Meta-analysis	k	n	r	SD_r	ρ	SD_ρ	80%CV	95%CI	%ARTV
Team behavioral process									
Compositional emergence	31	1,817	0.27	0.14	0.32	0.08	0.22-0.42	0.26-0.38	78.25
Compilational emergence	14	1,187	0.37	0.30	0.44	0.33	0.02-0.86	0.26-0.63	10.81
Team performance									
Compositional emergence	55	4,678	0.33	0.17	0.39	0.16	0.19-0.60	0.34-0.44	35.19
Compilational emergence	62	3,766	0.25	0.19	0.29	0.17	0.07-0.51	0.23-0.35	41.91

Notes: k, number of correlations meta-analyzed; n, total number of groups; r, sample size weighted mean observed correlation; SD_r, sample size weighted standard deviation of the observed correlations; ρ, sample size weighted mean observed correlation corrected for unreliability in both measures; SD_ρ, standard deviation of ρ; 80%CV, 90 percent credibility interval around ρ; 95%CI, 95 percent confidence interval around ρ; %SEV, percent variance due to sampling error; %ARTV, percent variance due to all corrected artifacts value around ρ (80%CV), the 95 percent confidence interval around ρ (95%CI), and the percent variance due to corrected artifacts (%ARTV). A ρ may be considered significant when its credibility interval does not include 0, as this would suggest that 90 percent of the true effect sizes for that relationship are greater than 0. ρs may be interpreted as being meaningfully different from one another when one ρ is not included in the confidence interval of the comparison ρ (Bobko and Roth, 2008; Kisamore, 2008; Kisamore and Brannick, 2008).

Table I presents the results of the relationship between team cognition and team process and performance. Consistent with the DeChurch and Mesmer-Magnus (2010) findings, team cognition is positively correlated with team process ($\rho_{cognition\text{-}process} = 0.38$, CV = 0.17-0.59) and performance ($\rho_{cognition\text{-}performance} = 0.36$, CV = 0.16-0.55).

Table II presents the findings for compositional (i.e. congruence and accuracy of SMMs) and compilational (i.e. transactive memory) emergence of team cognition. Consistent with the DeChurch and Mesmer-Magnus' (2010) findings, a stronger positive point estimate was found for the relationship between compilational emergence and team behavioral process than between compositional emergence and team behavioral process ($\rho_{compilational\text{-}process} = 0.44$, $k = 14$ vs $\rho_{compositional\text{-}process} = 0.32$, $k = 31$). However, we found the opposite to be true for team cognition and performance: the relationship between shared cognition and team performance is stronger for compositional emergence than for compilational emergence ($\rho_{compositional\text{-}performance} = 0.39$, $k = 62$ vs $\rho_{compilational\text{-}performance} = 0.29$, $k = 55$). This is opposite to the 2010 finding that compilational emergence had a stronger relationship with team performance than did compositional emergence ($\rho_{compilational\text{-}performance} = 0.44$, $k = 26$ vs $\rho_{compositional\text{-}performance} = 0.32$, $k = 33$). The ks in both of these analyses were nearly double those of the original database.

Meta-analysis	k	n	r	SD_r	ρ	SD_ρ	80%CV	95%CI	%ARTV
Team behavioral process									
Task	24	1,426	0.27	0.12	0.32	0.01	0.30-0.33	0.26-0.37	99.23
Team	26	1,828	0.35	0.22	0.42	0.22	0.13-0.70	0.32-0.52	24.09
Team performance									
Task	47	2,863	0.26	0.19	0.30	0.16	0.09-0.51	0.24-0.36	42.68
Team	75	5,592	0.30	0.16	0.36	0.14	0.18-0.54	0.32-0.41	44.46

Notes: k, number of correlations meta-analyzed; n, total number of groups; r, sample size weighted mean observed correlation; SD_r, sample size weighted standard deviation of the observed correlations; ρ, sample size weighted mean observed correlation corrected for unreliability in both measures; SD_ρ, standard deviation of ρ; 80%CV, 90 percent credibility interval around ρ; 95%CI, 95 percent confidence interval around ρ; %SEV, percent variance due to sampling error; %ARTV, percent variance due to all corrected artifacts

Table III. Content of cognition as a moderator of the cognition-process and cognition-performance relationships

	DV = team performance Model 1	Model 2
Team cohesion	0.228	0.161
Team behavioral process	0.151	0.097
Team cognition		0.249
df	1,391	1,393
R^2	0.117**	0.167**
ΔR^2		0.050**

Notes: All coefficients are standardized and significant at $p < 0.01$. ** $p < 0.01$

Table IV. Regression analysis examining unique contribution of team cognition to team performance

Table III reports the extent to which content of cognition (cognition about the team vs cognition about the task) moderates the relationship between shared cognition and team process and performance. Both content domains of cognition were positively related to team process and performance, but, consistent with prior findings, shared cognition about the team was more important to team process and team performance than was shared cognition about the task ($\rho_{team\ cognition\text{-}process} = 0.42$, $k = 26$ vs $\rho_{task\ cognition\text{-}process} = 0.32$, $k = 24$; $\rho_{team\ cognition\text{-}performance} = 0.36$, $k = 75$ vs $\rho_{task\ cognition\text{-}performance} = 0.30$, $k = 47$).

Next, we used regression analysis to examine the unique contribution of cognition to process and performance over variance attributable to team cohesion. We obtained six meta-analytic correlations to examine the joint impact of the drivers of team performance (i.e. motivational, behavioral, and cognitive). Two were estimated from this database ($\rho_{cognition\text{-}process} = 0.38$, $n = 2{,}973$; $\rho_{cognition\text{-}performance} = 0.35$, $n = 7{,}775$), one estimate was from the original DeChurch and Mesmer-Magnus (2010) database ($\rho_{cognition\text{-}cohesion} = 0.40$, $n = 425$), and two were estimates from LePine *et al.*'s (2008) meta-analysis ($\rho_{process\text{-}performance} = 0.29$, $n = 1{,}921$; $\rho_{process\text{-}cohesion} = 0.61$, $n = 619$), which were used in the DeChurch and Mesmer-Magnus (2010) meta-analysis. Finally, consistent with the DeChurch and Mesmer-Magnus analyses, the cohesion-performance relationship was drawn from Gully *et al.* (1995; $\rho_{cohesion\text{-}performance} = 0.32$, $n = 1{,}146$). Table IV reports the unique contribution of team cognition to team performance. First, we tested a model using team cohesion and process to predict team performance. Together these factors explained 12 percent of the variance in team performance. Then, we tested a model wherein team cognition was entered along with cohesion and process, and together these factors explained 17 percent of the variance in team performance, accounting for a significant 5 percent change in R^2 due to team cognition.

Discussion

With the trend toward teamwork growing every year (Jones, 2009; Wuchty *et al.*, 2007), revisiting questions like those posed in DeChurch and Mesmer-Magnus (2010) becomes critical. Meta-analyses do an adequate job of summarizing extant literature and highlighting major trends of the moment; however, they have the potential to become obsolete when their databases no longer reflect the extant literature (Ones *et al.*, 2017). With advancements in technology, the changing nature of work, and more taxing work environments, the trends of the last several decades may not hold in the future. Thus, periodical re-examination of meta-analyses should be conducted in order to have the most current and useful understanding of the literature. In 2010, DeChurch and Mesmer-Magnus found that team cognition had a significantly positive relationship with both team behavioral process and team performance. However, with nearly twice the number of studies on team cognition now available, we sought to understand whether and to what extent that relationship holds. Importantly, our results suggest that even with a balance of studies conducted in more contemporary teams and work environments, the overall role of team cognition in team process and performance holds in both direction and magnitude. Furthermore, the more precise analyses related to nature of emergence and content of cognition tended to be consistent with the 2010 findings.

Importantly, there was one interesting change in findings: whereas compilational emergence (e.g. transactive memory) was still more strongly associated with team behavioral process than was compositional emergence (e.g. SMMs; consistent with the 2010 findings), in this updated database, we found compositional emergence (e.g. SMMs) to be more strongly aligned with team performance than compilational emergence (e.g. transactive memory; which was reversed in the prior meta-analysis). In essence, this updated finding suggests that knowing who knows what (e.g. transactive memory) is more important to predicting effective and efficient team process, while having a shared understanding of the problem, task, or team (e.g. SMMs) is more influential in predicting the extent to which a team will be successful.

The change in this finding may be a function of the evolving team and work contexts that are studied today. Team environments are more specialized and distributed than they were in the past. Whereas knowing who to go to for what is useful in promoting efficient team process, perhaps the highly specialized and distributed teams of today must rely more on having a shared understanding of the problem, task, or team in order to be successful in accomplishing their objectives. For example, one of the more recent primary studies examined combat teams and found that it was more important to success of these teams when they aligned on the team goal(s) than it was to have specialized expertise (Ayoko and Chua, 2014). Likewise, as is discussed in *Team of Teams: New Rules of Engagement for a Complex World* by General Stanley McChrystal *et al.* (2015), military teams have had to adapt to the changing environment of combat – specifically, moving toward a shared view of each team's tasks in achieving the overall goal.

Limitations and directions for future research

As is the case with any meta-analysis, this study is limited by the availability of reported effect size estimates. For example, although such an examination would be quite useful in drawing conclusions regarding the role of team cognition in team process and performance, it was not possible to conduct a fully factorial moderator analysis of the various aspects of team cognition (e.g. nature of emergence, content of cognition) since there is an insufficient number of primary studies to permit such an examination. Future research examining team cognition in more diverse team types and teamwork settings and scenarios is needed so findings regarding team cognition's role in process and performance can be compared across team type and setting.

Second, we recognize that nature of emergence may be confounded with the trends toward studying SMMs and transactive memory in the extant literature. Although the difference between compositional and compilational cognition is similar to the difference between SMMs and TMSs, they are not the same. However, given our reliance on the availability of studies in the extant literature, we recognize that conclusions regarding nature of emergence may be associated with the tendencies for operationalizing SMMs and TMSs in the extant literature. New and more direct methods of measuring the process of emergence could lend insight into the nature of emergence of shared cognition (Kozlowski and Chao, 2012). Related to this idea, the compositional and compilational cognition distinction may also have a methodological distinction with implications for future research. To the extent compositional cognition is a latent measure, whereas compilational cognition is an emergent concept, what is unique to individuals will be included in compilational measures but only what is common across individuals will be included in compositional measures. If this is true, then a stronger correlation between compilational measures and team performance would not be unexpected. As we cannot tease apart this methodological distinction using meta-analysis, future primary research is needed to investigate this potential.

Third, research on the team cognition-team performance relationship operationalizes team performance in varied ways (e.g. using objective measures and subjective measures as well as self- and other-derived assessments). In team research, it is somewhat difficult to tease apart the unique effects of self vs other ratings, as typically self-rated performance is aggregated to the team level, which inherently includes other-rated performance. As such, it is a methodological question worthy of future research as to whether such performance operationalizations cloud our understanding of the role of predictors like team cognition in team performance.

Moving forward, it would be profitable for researchers to study teams operating in the sorts of more specialized and distributed environments faced by contemporary teams. Recognizing that today's teams operate in more complex and technologically sophisticated environments than before provokes new research questions. For example, for teams who work in constantly changing contexts, are there certain circumstances under which team cognition takes on greater/lesser importance? In what contexts is team cognition most important for various outcomes, and what forms or types of cognition are most influential in those conditions? Research directed toward understanding the intricacies of shared cognition within these extreme environments becomes critical if team cognition is to be generalizable to such contexts.

Additionally, research on team cognition has recently expanded toward several topic areas that should be considered for future research. In particular, membership mental models (i.e. knowledge structures that organize who is and who is not a member of what team; Mortensen, 2014) are a burgeoning area of team cognition research. It would be interesting to examine whether the relationships found in this paper hold when considering membership mental models. There is also a new research on temporal shared cognition (Mohammed and Nadkarni, 2014) that is concerned with understanding the time-related aspects of carrying out team tasks, or understanding who knows what in the team as well as when that knowledge is needed by the team. This new view on team cognition reflects the changing environments in which teams operate, and how those environments may impact team processes.

Conclusions

As reported by DeChurch and Mesmer-Magnus (2010), team process and performance are critically linked to team cognition, and this insight is replicated in the current meta-analysis. Interestingly, our new finding that compilational cognition is more important for team process while compositional cognition is more important for team performance highlights the changing nature of teams at work. Since the creation of the prior database, work teams and their tasks and dynamics have begun to change. More distribution, globalization, virtual communication, and sophistication in work tools, technologies, and processes have created new demands on teams, and have changed what aspects of team cognition are needed when. Future research must recognize and replicate the changing nature of teamwork if we are to fully understand the role of team cognition in teamwork process and performance. Finally, we hope to highlight the importance of updating meta-analyses with databases that include all current, relevant primary studies. As the nature of work and work teams change, updating our understanding of the role of key constructs in the workplace becomes crucial to advancing knowledge in the field.

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